# Investor Reactions to New Product Development Failure in the Biotechnology Industry

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# Abbreviations

| | |
|---|---|
| AMGen | Applied Molecular Genetics |
| biotech | biotechnology |
| CAR | Cumulative Abnormal Return |
| DNA | Deoxyribonucleic Acid |
| e.g. | exempli gratia (for example) |
| EPO PATSTAT | EPO Worldwide Patent Statistical Database |
| FDA | Food and Drug Administration |
| i.e. | id est (that is) |
| Inc. | Incorporated |
| IPO | Initial Public Offering |
| MIT | Massachusetts Institute of Technology |
| NASDAQ | National Association of Securities Dealers for Automated Quotation |
| NDA | New Drug Application |
| NPD | New Product Development |
| OECD | Organisation for Economic Cooperation and Development |
| OLS | Ordinary Least Squares |
| R&D | Research & development |
| RBV | Resource-based view |
| ReCap | Recombinat Capital database |
| ROA | Return on assets |
| SEC | Securities and Exchange Commission |
| TMT | Top Management Team |
| US | United States |
| VC | Venture Capital |
| VIF | Variance Inflation Factor |

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# 1 Introduction

Between the close of the NASDAQ stock market on Friday, March 7, 2008, and the opening of the market on the subsequent Monday—March 10, 2008—Keryx Biopharmaceuticals (NASDAQ: KERX) lost $4.51 per share in value, falling from $5.26 to $0.75. What happened to Keryx Biopharmaceuticals? Why did the company's stock price fall so dramatically? Substantial negative investor reactions are not infrequent in the biotechnology industry when companies announce that promising new product development (NPD) projects have failed to achieve desired milestones. Contingent on the development stage of the failed NPD project, as well as the reason for failure, investor reactions to failure announcements vary widely, possibly leading to significant losses in market valuation or to firm insolvency (De Carolis et al., 2009; Sharma and Lacey, 2004). In case of Keryx Biopharmaceuticals, the company announced that the Phase III trial of Sulonex had failed to meet a primary efficacy endpoint. Subsequent to this bad news announcement, investors punished the firm and its stock price resulting in a loss of market value by almost 86% percent.

Literature shows that due to the long new product development cycles, combined with high technological and market uncertainty, NPD failure rates in the biotechnology sector are very high (Himmelmann and Schiereck, 2009; Rothaermel and Hess, 2007). In this industry only one out of every 5,000 initial NPD candidates reaches the market (Evans and Varaiya, 2003), and that even if a potential new drug makes it to clinical trials, there is still an 80% likelihood that it will fail (Abrantes-Metz et al., 2005). Furthermore, literature shows that NPD

failures are also frequent in other innovation-driven industries, such as telecommunications (Buganza et al., 2009) and software (Ethiraj, et al., 2009).

Failure of NPD projects impacts the attractiveness of stock return for investors (Girotra et al., 2007; Sarkar and de Jong, 2006) because profit expectations are significantly affected by the announcements of organizational events influencing future firm performance (Lee and Chen, 2009). The announcement of NPD outcomes is a signal to investors about the firm's current state and its ability to generate cash flows in future. While in some industries NPD failures are not obvious to investors and thus have only little impact on stock prices, in the American biotechnology industry, NPD failure is clearly clarified and highly visible due to strict regulation by the Food and Drug Administration (FDA).

As illustrated in Figure 1, biotechnological NPD failures can result in substantial losses in firm market value. However, as the two example cases show, not all firms suffer equally after failure. While the market value of Keryx decreased by almost 86% after failure announcement, Actelion only lost 4% in market value.

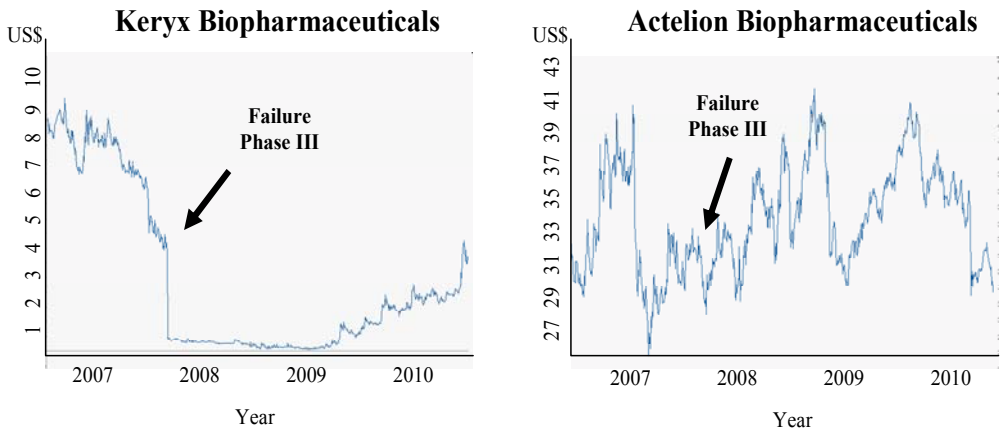


**Figure 1: Variance in investor reaction to NPD failure announcement**

**Source: NASDAQ homepage**

Why did the stock market react so differently to the NPD failure announcement by Keryx and Actelion? How can we explain variance in investor reactions to NPD failures? Just recently scholars have started to address this question. For example, research on the financial impact of new product development failures mainly focuses on failed NPD projects of US biotechnology firms developing new drugs for the treatment of human diseases because (i) this sector exhibits one of the highest R&D intensities since firm success depends on continuous innovation based on risky NPD projects (Rothaermel and Hess, 2007; Rzakhanov, 2004), and (ii) most US biotechnology firms are publicity traded thus allowing studies to access relevant data for representative sample sizes (De Carolis et al., 2009; Buerger et al., 2010). However, due to the relative newness of the biotech sector, we have only a limited understanding of the consequences of NPD failures, especially the financial consequences for innovative firms.

Therefore, industry-specific knowledge of how investors behave after an NPD failure announcement is of utmost importance for researchers and biotech practitioners, such as firm managers and investors in order to better understand financial consequences after NPD projects fail. For management scholars, systematic research in this particular field is necessary to develop and empirically verify NPD and management theory specific to the biotechnology context. For practitioners, the answers to these questions can lead to better strategic planning taking into account potential consequences of NPD failure. Therefore the aim of this thesis is to analyze different aspects of investor reactions to NPD failures in the

biotechnology industry and to deepen our understanding of the consequences of failures for innovative firms.

The reminder of this introductory chapter is structured as follows. In section 1.1 I look at the emergence and economic importance of the biotechnology industry in the United States. This is followed by an overview over the basic framework of this thesis (section 1.2) and the event study methodology that unifies all research questions addressed in this work (section 1.3). Finally, I present the topics and the structure of this thesis in section 1.4.

### 1.1 The emergence and economic impact of the US biotechnology industry

Biotechnology is not a new field. About 500 B.C. the Chinese discovered that moldy soybean curd could help to treat boils. However, the modern commercial biotechnology's scientific roots are in the United States (Russo, 2003). The birth of this sector is often traced to the establishment of Genentech in 1976, the first biotechnology company in the world (Kenney, 1986). The webpage of the Genentech describes this event as follows (Genentech, 2010):

> In the early 1970s, the biochemist Dr. Herbert Boyer and the geneticist Stanley Cohen pioneered a new scientific field called recombinant DNA technology. Upon learning about this development, the venture capitalist Robert A. Swanson placed a call to Boyer and requested a meeting. Boyer agreed to give the young entrepreneur 10 minutes of his time. Swanson's enthusiasm for the technology and his faith in its commercial potential were contagious, and the meeting extended from 10 minutes to three hours; by its conclusion, Genentech was born.

After the foundation of Genentech, the biotech sector in the United States grew quickly. In the following years, a flood of bioentrepreneurs entered the scene. For example, in 1978 the Harvard professor Walter Gilbert and Philipp Sharp from

the Massachusetts Institute of Technology (MIT) set up the company Biogen. Only two years later, in 1980, AMGen (Applied Molecular Genetics) was founded and pioneered the development of novel and innovative new products based on advances in recombinant DNA and molecular biology (Maraganore, 2009).

In the ten years following Genentech's foundation, the US biotech sector grew to include more than 800 firms and more than 4,000 employees (Ernst & Young, 2001). Despite some periods of hostile financing environments, such as the economic downturn of 1993-1995, the number of firms and employees in this innovation-driven sector continued to grow. By 1997, the biotechnology industry in the United States included 1,274 companies with more than 140,000 employees (Ernst & Young, 2003).

One favorable precondition for the growth of the sector was the capability of biotechnology firms to identify new ideas from research universities and government laboratories (Kenney, 1986). Moreover, the existence of venture capital (VC) investors, who are willing to bear high failure risks related to the new and disruptive technologies, plays an important role for the development of the biotechnology industry in the US (Prevezer, 2001). Finally, the whole sector benefited from Genentech's success that convinced other bioentrepreneurs and investors to enter the industry (Kenney, 1986).

The impact of modern biotechnology has increased over time and its influence is widespread. With respect to medicine and pharmacy, history shows that biotechnology in this particular field "is the only chance to develop treatments against cancer, AIDS, Alzheimer's and other diseases." (WIPO, 2000). Moreover,

with a population increasing in median age, focus on age-related and chronic diseases is steadily rising. Biotech firms have focused on finding cures for these diseases with an increasing number of drugs approved by the FDA (as illustrated in Figure 2). This led to the cure of many diseases that were previously fatal and consequently, healthier populations.

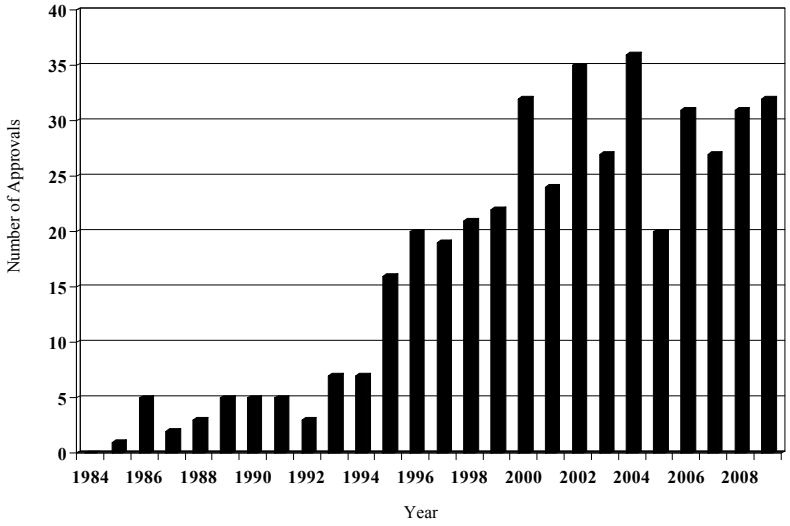


**Figure 2: Approvals of new biotechnology drugs**
**Data from Biotechnology Industry Organization (2010)**

Due to the enormous economic potential that biotechnology offers, as well as the opportunities to advance other industries such as agriculture, organic chemicals or even oil drilling (Kenney, 1986), investors quickly recognized the growth opportunities for biotechnology firms. For example, when Genentech went public on October 14, 1980, its stock price climbed from IPO price of $35 to $89 in one day (Genentech, 2010). The company's value has since grown steadily, and in 2009 Genentech reached a market capitalization of more than $100 billion (NASDAQ, 2010). As of December 2008, the company employed more than 11,000 employees with revenues of US$13.4 billion (Genentech, 2010).

However, where there is upside potential there is also downside potential. Investors in biotechnology firms, especially in firms developing new drugs, face substantial risks in transforming basic research into marketable new drugs, as this is a complex, capital-intensive, and highly risky endeavor. Based on strict regulated guidelines, each potential new drug must pass through a number of defined stages before market approval (Girotra et al., 2007; Xu et al., 2007). As illustrated in Figure 3, a new drug development process starts with discovery and basic research in the lab, followed by pre-clinical studies where the new drug candidate that emerges from the laboratory research is tested in animal studies. Subsequently, each potential new drug must be tested in three clinical stages to ensure both the safety and effectiveness in human subjects (Abrantes-Metz et al., 2005; Evans and Varaiya, 2003). Following this a New Drug Application (NDA) review process must be completed before the FDA can approve the new drug for the US market (Sarkar and De Jong, 2006; Rzakhanov, 2004).

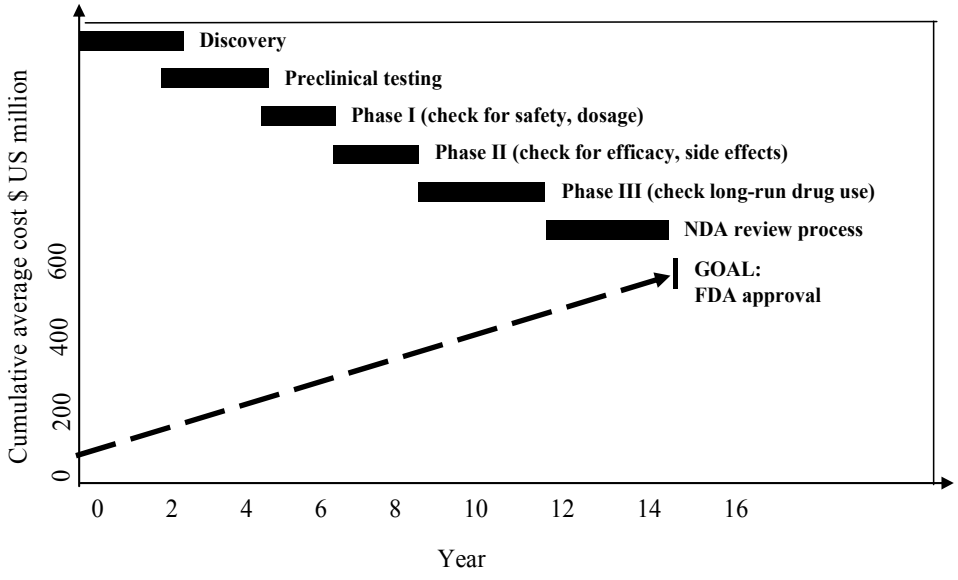


**Figure 3: New drug development process**

**Source: Own illustration, Data from Girotra et al. (2007)**

The entire new drug development process can take more than 15 years (Evans and Varaiya, 2003) and typically costs at least $600 million for a single drug (Moran, 2003). Due to this time and capital intensive multi-step process, as well as the public visibility of NPD outcomes through FDA disclosure requirements, research finds that failed NPD projects can significantly harm market value of these firms (De Carolis et al., 2009; Girotra et al., 2007). However, existing studies neglect to investigate why this effect differs across firms and what factors drive this variation in investor reactions after failure. Investigating this gap in the research is of utmost importance, in order to provide a more fine-grained understanding of investor reactions to failures of NPD projects.

**1.2 The basic framework of this thesis**

Our knowledge of financial consequences of NPD failure and investor reactions to failure is still limited. How do firm specific capabilities impact stock market response after NPD failure announcement? Do investors react differently to NPD failure depending upon which development stage the NPD project fails? What role does managerial experience within the firm's top management team (TMT) play within the failure context? How does simultaneously announced good news regarding other NPD projects impact firm market value after failure? And, finally, do large patent stocks owned by innovative firms enhance or diminish the impact that NPD failure has on firm valuation in financial markets?

In order to find answers to these research questions I combine findings from the new product development literature with existing research on the resource based view of the firm, organizational capabilities, Upper Echelon theory, news

announcement effects, and patent literature to investigate the joint impact of firm characteristics at (i) the *product level*, (ii) the *managerial level* and (iii) the *organizational level* on firm market valuation after NPD failure. Figure 4 visualizes the basic idea underlying this thesis.

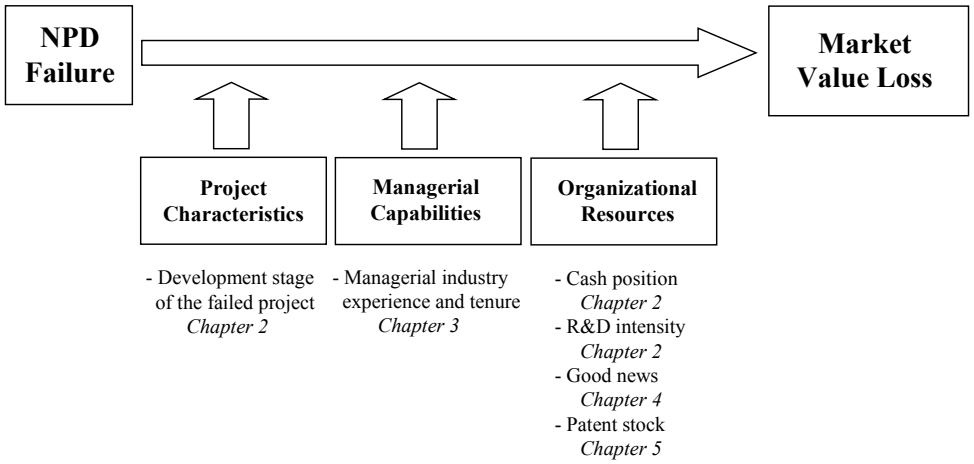


**Figure 4: Basic framework of the thesis**

**Source: Own illustration**

As outlined above, scholars recently started investigating why failures harm some companies more than others (De Carolis et al., 2009; Girotra et al., 2007), and typically draw on one of two possible theoretical perspectives. Some studies argue from an *ex ante perspective*, suggesting that investor expectations of NPD outcomes before the failure determine the decline in firm market value in the event of an NPD project failure. In other words, as investors perceive NPD success to be more and more likely, the greater the decline when NPD failure occurs (Sharma and Lacey, 2004; Kellogg and Charnes, 2000). In contrast, some scholars take an *ex post perspective* arguing that investor reactions to NPD failure are mainly driven by their perception of the firm's ability to successfully recover after the NPD failure

(De Carolis et al., 2009; Girotra et al., 2007). This perspective suggests that the better investors perceive a firm's recovery potential, the smaller the decline in firm market value in the event of NPD failure.

In this thesis, I aim to integrate both perspectives by investigating which perspective prevails and under which contingencies. I propose that the influence of NPD failure on market value of biotechnology firms is not only contingent on the firm properties at the *product-level*, but also on other capabilities at the *managerial level* and the *organizational level*.

### 1.3 Methodological choice

To test my hypotheses I perform four event studies using data on NPD failures by publicly traded US biotechnology firms. Event study methodology is well suited to capture the impact of firm-specific events on market valuation (Kothari and Warner, 2004; McWilliams and Siegel, 1996) and is applied to a wide variety of events in the finance and accounting literature. For instance, this technique has been used to investigate the impact of earnings announcements (Mendenhall and Nichols, 1988), mergers and acquisitions (Shusterman et al., 2000), and corporate downsizing actions (Nixon et al., 2004) on firm market valuation. In the management literature, event studies focus on the consequences of outsourcing announcements (Agrawal et al., 2006), job loss announcements (Farber and Hallock, 2009), and CEO deaths (Bennedsen et al., 2007). Notable applications from the product development literature investigate how firm market value is affected by new product introductions (Chaney et al., 1991), delays in new product

introductions (Hendricks and Singhal, 2008), and new product recall announcements (Govindaraj and Jaggi, 2004).

The usefulness of an event study technique, however, depends on a set of key assumptions (Binder, 1998; Brown and Warner, 1985). Firstly, this methodology is based on the efficient-market hypothesis (Fama, 1970) suggesting that *"the security price at any time fully reflect all available information"* (Fama, 1970: 383). Since stock prices reflect investor perceptions of future returns, they should reflect the market reaction to the introduction of new information (McWilliams and Siegel, 1997). Second, it is assumed that the announced event can not be anticipated by the market in a way that the market previously did not have information on the event (Govindaraj and Jaggi, 2004; MacKinlay, 1997). Third, the most critical assumption for the use of an event study technique refers to potential confounding events. It is assumed that there are no confounding effects from other events that might impact the stock price during the event period (Wells, 2004; McWilliams and Siegel, 1997).

The first step of the event study procedure is the identification of the event and the event period (e.g., the event window) over which to evaluate stock returns (MacKinlay, 1997, Bowman, 1983). After the event determination, the firms that might be affected by the event have to be identified. In the next step, the 'normal' changes in stock prices for the firms have to be estimated. Therefore, several methods are available, including the mean-adjusted model, the market-adjusted return model, and the OLS-market model (Armitage, 2006; Thompson, 1985). Brown and Warner (1985) show that the market-adjusted returns model and the

OLS-market model have more power than the simpler mean-adjusted returns model, and in the case of daily data both techniques have similar power. This is consistent with Henderson (1990) who argues that the power of the market-adjusted return model and the OLS-market model is comparable.

Following this reasoning, in this thesis, abnormal returns were derived via a market-adjusted returns model (e.g., Hendricks and Singhal, 2008; Girotra et al., 2007) using the NASDAQ Biotechnology Index as a market proxy in order to control for confounding events that are industry-specific. All market-adjusted returns were calculated by measuring *market value loss* as the relative difference between the price of the benchmark index and the firm stock price. As illustrated in Figure 4, this variable serves as the dependent variable in all four event studies presented in this thesis. Following previous research on event study methodology (McWilliams and Siegel, 1997; Henderson, 1990; Brown and Warner, 1985), this variable is operationalized as Cumulative Abnormal Return (CAR), which captures the impact of NPD failure on market valuation of biotechnology firms (De Carolis et al., 2009; Himmelmann and Schiereck, 2009). Therefore, the individual abnormal returns were cumulated by summing the daily abnormal returns during a three-day event window (Girotra et al., 2007; Serra, 2002; Mc Williams and Siegel, 1997). To ensure robustness of the results, I also calculated alternative event windows that were all defined with respect to trading days in the US (De Carolis et al., 2009; Nixon et al., 2004).

Of course, no method is free of limitations. Since I explicitly focus on firms included in the NASDAQ Biotechnology Index to better operationalize the relative

difference between the index and the firm's stock price after NPD failure, my measure of CAR is incomplete to the extent that focal firm losses in stock price influence the performance of the index itself. Although my approach is consistent with Hendricks and Singhal's (2008) arguments that measurement of the CAR by using a fitting index is beneficial to avoid confounding events, more work is needed to investigate alternative measures of abnormal returns in this context. Finally, my approach is limited by the fact that the timing and framing of the failure announcement can influence investor's perception of the firm. These limitations should be noted when using event studies in this field (De Carolis et al., 2009; Himmelmann and Schiereck, 2009). I discuss and explain how I overcome these shortcomings in each chapter of this thesis.

### 1.4 Structure and scope of this thesis

This thesis consists of four event studies investigating investor reactions to NPD failures in the US biotechnology industry from different perspectives. Specifically, these focus on the impact of the development stage of the failed NPD project in concert with organizational capabilities, managerial capabilities of the firms top management team, simultaneously announced good news regarding other NPD projects, and patent stocks on investor evaluation of biotechnology firms after NPD failure. I dedicate a separate chapter to each phenomenon. Each chapter is introduced by a general topic description to frame it within the context of existing research. I then discuss the outcomes and implications of each analysis, highlight its limitations, and suggest potential for future research.

The following chapter, chapter 2 focuses on financial, innovative, and managerial capabilities because these capabilities are known to be critical to performance of biotechnology firms (Rothaermel and Hill, 2005; Galende and De la Fuente, 2003; Henderson and Cockburn, 1994). Moreover, these capabilities are (to a certain extent) observable by investors (De Carolis et al., 2009; Girotra et al., 2007; Napshin and De Carolis, 2007). I propose that these capabilities impact investor assessment of NPD failures by influencing their (i) *ex ante expectations* that the NPD process will be completed successfully and (ii) *ex post expectations* that the firm will recover from failure. Interestingly, both expectations lead to competing hypothesis that I analyze using hierarchical moderated regression analysis. My results show that after NPD failure biotech firms loose on average about US$252 million in market value. My data further reveals that capabilities such as the high cash position or high R&D intensity of the firm can significantly enhance this negative effect. I also show that these effects differ significantly depending on the development stage during which the NPD project fails. This study sheds new light on how investors react to failed NPD projects and provides both theoretical implications for researchers and practical conclusions for firm managers.

In chapter 3, I focus on the role of managerial experience on investor perception of negative NPD outcomes. More specifically, I examine the impact of managerial experience within the firm's top management team on firm market valuation after announcing an NPD failure and how this impact can be moderated by firm specific resource endowments. Combing resource based theory (Barney,

1991) with the Upper Echelon perspective (Hambrick and Mason, 1984), I propose that TMT industry experience and TMT tenure can mitigate the impact of firm resources on firm value decline. To test my hypotheses I use only data on late stage NPD failures since they are known to result in sharp losses in firm market values and preventing these huge losses appear a major managerial challenge. My data provide support for the hypothesis on the moderating effect of TMT industry experience, but not for TMT tenure. This finding contributes to the Upper Echelon literature and indicates that investors regard managerial experience that goes beyond organizational boundaries as more beneficial for overcoming failure than firm-specific managerial experience. In conclusion, this study advances our understanding of investor perceptions of failures by emphasizing the signalling role of managerial experience in the context of adverse events.

The study presented in chapter 4 sheds new light on how investor reactions to failures can be influenced by the way companies communicate NPD failure to financial markets. I draw on resource-based arguments and propose that in context of NPD failure the positive effect of parallel announced good product news is contingent on firm specific variables. I show that (i) simultaneously announced good product news can counterbalance negative investor reactions to NPD failures and (ii) this positive effect substantially depends on firm R&D intensity, cash position, and corporate revenues. These findings add to NPD literature since prior studies have not explicitly controlled for good news in the context of NPD failure announcements, but ignored events where good and bad news occur in parallel. Further, explicitly addressing the effect of good news in the context of NPD failure

announcements improves our understanding of investor reactions to failure, as ignoring these not uncommon events might bias results. In fact, it appears that parallel announced good news significantly alters the impact that firm specific variables have on market value after NPD failure suggesting that these factors need to be considered *conjointly* to gain a more complete understanding of the consequences of failed NPD projects.

In chapter 5 I examine the role of the company's intangible assets after NPD failure announcement. Here I focus on the role of patent stocks in the NPD failure context since existing patent literature highlights patents as a key resource that investors use to build their expectations regarding future cash flows and returns (Levitas and McFadyen, 2009; Himmelmann and Schiereck, 2009). My theoretical arguments suggest that due to disappointed market expectations, patent stocks negatively impact investor reactions after NPD failure. I test my hypotheses using the EPO World Patent Statistical Database (PATSTAT) to obtain the patent data for all NASDAQ listed biotechnology firms experiencing NPD failure between 1994 and 2008. My results indeed show that patents negatively impact stock market response to NPD failure. Interestingly, in addition I find that for very large patent stocks buffering effect can also occur, presumable because large patent stocks suggest that the firm has the potential to overcome NPD failures. This buffering effect, however, depends on the firm's R&D strategy, which affects the quality and structure of its patent stock. Although prior studies in the NPD and patent literature have shown that investors react to NPD outcomes (De Carolis et al., 2009; Hendricks and Singhal, 2008) and highlighted the beneficial role of patent stocks

on firm market values in general (Chen and Chang, 2009; Harhoff et al., 2003), the role of patent stocks during NPD failure is still unexplored. By explicitly addressing how patent stocks affect firm market value after NPD failure, I fill this gap and contribute to improving our understanding how patents influence investor reaction.

Finally, in chapter 6 I summarize the outcomes of this thesis and its contributions to existing research. I draw final conclusions and suggest potential research areas for future research in the field of new product development failures and the financial consequences for innovative companies.

# 2 Organizational capabilities and investor reactions to new product development failures[1]

In this chapter I investigate how investors react to new product development failures contingent on the role of firm capabilities and the development stage of the failed product. I integrate two theoretical perspectives to develop a model proposing that a firm's financial, innovation, and managerial capabilities either enhance or diminish the decline in firm market value after NPD failure, contingent on the development stage of the failed NPD project. Data of NPD failures by publicly traded biotechnology firms support wide parts of the model and highlight the importance of a conjoint consideration of both product- and organizational-level effects in explaining investor reactions to negative NPD outcomes. In Section 2.1 I provide an introduction to the topic. Then I review literature on firm capabilities and new product development failure and derive my hypotheses in Section 2.2. I explain the event study methodology used in Section 2.3 and present the results of the study in Section 2.4. Finally, in Section 2.5 I discuss these results and suggest opportunities for future research.

[1] This section is based on Buerger, Patzelt, Urbig and Schweizer (2010). An earlier version of the paper (Buerger, Patzelt and Schweizer, 2009) was presented at the Babson College Entrepreneurship Research Conference, June 4-6, 2009, in Babson Park, MA, USA and published in the conference's best paper proceedings. Frontiers of Entrepreneurship Research.

## 2.1 Introduction

Although a substantial body of literature has advanced our understanding why new product development projects succeed or fail (Edmondson and Nembhard, 2009; Cooper and Kleinschmidt, 2007; Dwyer and Mellor, 1991; Montoya-Weiss and Calantone, 1994), failure rates in innovation-driven industries are still high. For example, in the biotechnology industry only one out of 5000 initial product candidates reaches market launch (Evans and Varaiya, 2003), and even when a potential new drug passes the research stage and enters into clinical development more than 80% of new product candidates fail (Abrantes-Metz et al., 2005; DiMasi et al., 2003). High NPD failure rates are also reported in other innovation-driven sectors such as telecommunication (Buganza et al., 2009), software (Ethiraj et al., 2009), and electronics (Terwiesch et al., 1998).

Only recently scholars have started to investigate why NPD failures harm the market value of some firms more than others (De Carolis et al., 2009; Girotra et al., 2007; Sarkar and de Jong, 2006). These studies typically draw on one of two possible perspectives. First, some scholars take an ex ante perspective and argue that investor expectations of new product development before the failure determine the decline in firm market value when NPD projects actually fail – the higher investors' perceptions of the likelihood of success, the larger the decline (Sharma and Lacey, 2004; Kellogg and Charnes, 2000). In contrast, other studies argue from an ex post perspective and suggest that investors' reactions to NPD failures are mainly determined by perceptions of firms' abilities to recover after the failure – the better investors perceive a firm's recovery potential, the smaller the valuation

decline (De Carolis et al., 2009; Guedj and Scharfstein, 2004). While studies taking either perspective have improved our understanding of how investors react to NPD failures, they have not investigated which perspective prevails and under what contingencies. Investigating this research gap is important to provide a more fine-grained understanding of investor reactions to failures of NPD projects.

This paper develops a model that integrates ex ante and ex post perspectives on NPD failures, and includes organizational-level and product-level characteristics, as well as their interactions, in explaining variance in investors' reactions to NPD failures. We draw on capabilities-based arguments suggesting that firms need the appropriate stock of available assets and the capacity to deploy those assets to achieve a desired end result (Amit and Schoemaker, 1993). We define capabilities as the set of abilities and resources that go into solving a problem or achieving an outcome (Zahra et al., 2006). This definition includes what strategy scholars have termed "resources" in the resource-based view (Barney et al., 2001; Wernerfelt, 1984). Our model proposes that both ex ante and ex post arguments can explain the impact of organizational capabilities on investors' reactions to NPD failures, but that the development stage of the failed product influences the prevalence of each perspective. We test our model using an event study methodology and data on 166 NPD failures of publicly traded biotechnological firms. In doing so, we make the following contributions to existing literature.

First, the NPD literature demonstrates that prior firm performance (De Carolis et al., 2009), the availability of cash (Xu et al., 2007), and the composition

of the product portfolio (Girotra et al., 2007) influence to what extent firm performance declines after NPD failure. These studies, however, do not distinguish between products with different properties. This distinction appears important because different products require a different set of organizational capabilities for successful development (George, 2005; Abrantes-Metz et al., 2005). Our model acknowledges variance in the development stage of failed products, and that the capabilities needed for successful completion of these stages vary. Our finding that the impact of financial, innovation, and managerial capabilities on firm performance after NPD failures is contingent on the product's development stage emphasizes that organizational-level and product-level factors need to be considered conjointly rather than independently to gain a more detailed understanding of the performance consequences of NPD failures.

Second, research on the antecedents and outcomes of innovation processes usually focuses on one level of analysis while neglecting heterogeneity at other levels and that those levels may not be independent of the level under investigation (Rothaermel and Hess, 2007). Our study suggests that organizational-level factors can mitigate negative outcomes of innovation processes (NPD failures), but that these effects are not independent of heterogeneity at the level of the product under development. Our data support this view and highlight the importance of cross-level effects in the investigation of organizational outcomes of innovation processes.

Third, while recent studies show that investors do react to the outcomes of NPD processes (Hendricks and Singhal, 2008; Alefantis et al., 2007; Guedj and

Scharfstein, 2004; Sharma and Lacey, 2004), our article suggests that this reaction is more complex than has been assumed previously. Existing studies propose and find a linear relationship between characteristics of organizations that experience NPD failures and investor reactions to those failures (De Carolis et al., 2009; Sarkar and de Jong, 2006; Rzakhanov, 2004). Our results challenge this simplifying view by demonstrating that investor perceptions of NPD outcomes incorporate contingency relationships between organizational and/or product-specific characteristics.

This paper proceeds as follows. First, we develop our model and hypotheses. Second, we describe the research method and results of our study. Finally, we discuss its outcomes and implications, highlight its limitations, and draw conclusions.

**2.2 Theory development**

While performance implications of NPD failures are indicated by a variety of organizational outcomes such as products in pipeline (De Carolis et al., 2009), sales (Girotra et al., 2007), and inter-firm collaborations (Campart and Pfister, 2007), they are ultimately judged by the attractiveness of stock returns for investors (Sarkar and de Jong, 2006; Sharma and Lacey, 2004). Stock returns are affected by the announcements of organizational events influencing future organizational performance (Lee and Chen; 2009; Hendricks and Singhal, 2008). The announcements of NPD outcomes signal to investors the firm's current state and its ability to create cash flows and gain competitive advantage in the future. While in

some sectors NPD failures are not obvious to investors and thus have little impact on stock returns, in other sectors such as biotechnology they are highly visible.

The development of new drugs is a multi-step process with the steps being clearly defined by regulatory guidelines (Girotra et al., 2007; Sarkar and de Jong, 2006). After the research phase, new drug candidates must pass the pre-clinical testing phase and three subsequent clinical phases before entering into the regulatory approval phase that results in either permission or prohibition to market the product. The outcomes of these development steps and the firms' decisions to continue or terminate the development process at each step are publicly announced due to regular SEC disclosure requirements. Due to their public visibility, often NPD outcomes have a substantial effect on biotechnological firms' market value (De Carolis et al., 2009; Girotra et al., 2007; Sarkar and de Jong, 2006; Rzakhanov, 2004; Sharma and Lacey, 2004).

While NPD failures in biotechnological firms indicate the loss of an important capability (the failed product, Patzelt et al., 2008; Rothaermel and Deeds, 2006), firms are bundles of capabilities and the effective combination and interaction of capabilities is necessary for high performance and sustained competitive advantage (Eisenhardt and Martin 2000; Teece et al., 1997). New product development requires a variety of different capabilities (Lee and Chen, 2009; Montoya-Weiss and Calantone, 1994) which influence investors' expectations about NPD outcomes and firm performance. That is, the impact of NPD failures on firm market value is not only contingent on the failed product's properties, but also on other capabilities available to the firm.

In this study we focus on financial, innovative, and managerial capabilities because these types of capabilities are critical to the performance of firms developing new products (Rothaermel and Hill, 2005; Evans and Varaiya, 2003; Galende and De la Fuente, 2003; Henderson and Cockburn, 1994) and (to a certain extent) observable for investors (De Carolis et al., 2009; Girota et al. 2007; Napshin and De Carolis, 2007; Rzakhanov, 2004). We propose that financial, innovative, and managerial capabilities influence investors' assessments of NPD failures by impacting their (i) *ex ante expectations* that the NPD process will be successful and (ii) *ex post expectations* that the firm will successfully recover from failure. Both expectations will lead to competing hypotheses, which we now offer.

**Investors' ex ante expectations and NPD failure**

*Financial capabilities* refer to the slack available that can be used to develop the firm's capability base (George, 2005; Nohria and Gulati, 1996). More specifically, high discretion financial slack denotes the cash and cash equivalents available to the firm (Patzelt et al., 2008; Mishina et al., 2004). In contrast to low discretion financial slack (debt) which provides less strategic flexibility to managers, high-discretion financial slack can be diverted or redeployed to particular organizational activities such as NPD. Before NPD projects fail, the availability of high discretion slack will increase investors' expectations that the NPD process will be completed successfully, and that the firm will appropriate the rents from this successful NPD.

First, strategic flexibility provided by high discretion slack allows firms to acquire the capabilities they need for successful NPD even if unforeseen difficulties arise. For example, during the NPD process key scientists may want to leave the firm leading to loss of important knowledge and skills necessary for continuing NPD. Firms with cash available can try to keep these scientists by offering salary increases, or they can hire new, highly qualified scientific personnel compensating at least partly for the knowledge lost (Rzakhanov, 2004; Guedj and Scharfstein, 2004). Cash reserves also allow firms to continue with NPD in the face of unexpected increases in raw material prices. Further, cash offers the opportunity to buy new devices that could facilitate the NPD process. To acquire the capabilities needed for NPD, firms with more cash can even take the expensive option of acquiring other firms (Rothaermel and Deeds, 2004).

Second, high discretion financial slack allows firms to maintain control over their new product candidates and appropriate the rents generated once this candidate has entered the market. When firms are low in cash, often the only way to finalize NPD is to enter into strategic alliances with incumbent firms providing the assets required (Core et al., 2006; Rothaermel and Hill, 2005). Not only do these joint NPD efforts result in a sharing of revenues between the allying firms (Bhaskaran and Krishnan, 2009; Gimeno, 2004), but also the likelihood that the alliance and thus the NPD project fails increases when the firm is in a weak cash position. This is because incumbent alliance partners tend to exploit a strong negotiation position and over-control the alliance leading to increased alliance failure rates (Lerner et al., 2003). Further, even if the firm has sufficient capabilities

to develop the new product candidate internally, substantial amounts of cash can be required to defend a patent associated with new products, particularly in highly competitive environments such as biotechnology where imitation is likely and some patents are of questionable strength (Lerner and Merges, 1998).

In sum, before an NPD failure a strong cash position signals to investors that firms have opportunities to acquire the capabilities required for, and the flexibility to meet challenges associated with, successful NPD, and that they will appropriate the full profits once the new product has entered the market. Thus,

*Hypothesis 1a: When NPD projects fail, the more cash available to a firm the larger the decrease in market value.*

*Innovation capabilities* denote a company's ability to create internal knowledge and use it to produce marketable compounds (Subramaniam and Youndt, 2005; Rzakhanov, 2004). Innovation capabilities are also essential to take advantage of external knowledge, to generate early cash flows, and to sustain competitive advantage (Schoonhoven et al., 1990). An indicator of a firm's innovation capabilities is its R&D intensity (De Carolis et. al, 2009; Cohen and Klepper, 1992; Hill and Snell, 1988; Xu et al., 2007). R&D investments positively impact firm performance given that the firm allocates these investments in a way that the product pipeline balances long development cycles and low success rates (Girotra et al., 2007; Cohen and Levinthal, 1990).

High R&D intensity signals to investors that a firm invests comparatively more of its capabilities into the development of new product candidates than firms with

low R&D intensity. That is, high R&D firms' products under development may be higher in quality and more likely to reach market launch (Xu et al., 2007). For example, if a firm invests a substantial part of its capabilities in the development of a prototype, this prototype and its compounds have been extensively tested in the laboratory and field studies. In the biotechnology industry, high R&D intensity indicates extensive and thoroughly conducted laboratory and animal testing, and only those drug candidates that pass all the tests are moved forward to clinical development. In contrast, low R&D intensity indicates that firms only conduct a minimum of laboratory and pre-clinical tests, and these firms' product candidates entering clinical development could have been subject to more sophisticated analysis and selection before further development. Before an NPD failure, investors will therefore expect a higher likelihood of success for new product candidates of firms with high R&D intensity than for new product candidates of firms investing less in R&D (Huang et al., 2009; Rzakhanov, 2004). Thus,

*Hypothesis 1b: When NPD projects fail, the higher the R&D intensity of a firm the larger the decrease in market value.*

*Managerial capabilities* refer to the abilities and know-how of a firm's Top Management Team (Zhang and Wiersema, 2009; Jensen and Zajac, 2004). The TMT covers *"all executives with title above the rank of vice president or serving on the firm's board of directors"* (Cannella et al., 2008: 773). A firm's TMT takes decisions to adapt the firm's strategy to environmental demands and thus influences performance (Marcel, 2009; Ling et al., 2007; Jensen and Zajac, 2004). Since mental models of TMTs and thus the decisions they take depend on the

characteristics of the team members (Hambrick and Mason, 1984), the composition of the TMT serves as an important signal for investors regarding a firm's future performance (Canella et al., 2008; Napshin and De Carolis, 2007).

Industry experience of the TMT appears a particularly important indicator of managerial capabilities because it is crucial for the performance of firms developing new products (Naranjo-Gil, 2009; Carpenter et al., 2004). Industry experience *"embeds tacit knowledge of opportunities, threats, competitive conditions, technology, and regulations specific to an industry, as well as goodwill, with industry players such as buyers and suppliers"* (Kor and Misangyi, 2008: 1346). TMT industry experience raises investor expectations about successful NPD since industry experience indicates TMTs' market specific knowledge and industry specific networks (Cohen and Dean, 2005; Eisenhardt and Schoonhoven, 1990).

First, the more market knowledge a TMT has, the more likely it will develop products that meet customer demands and are launched successfully. This may include focusing only on products in market segments where competition is modest, developing products in accordance with industry standards and guidelines, and choosing market segments that are large enough to achieve high returns. For example, for new drug development TMTs with experience in the biotechnology industry will select therapeutic areas with little competition but substantial medical demand. Further, experienced TMTs are likely to design the clinical development process in a way that it complies with regulatory industry guidelines but at the same time minimizes costs and maximizes success probabilities.

Further, as compared to less experienced TMTs, more experienced teams can leverage their extensive industry networks to increase the success probabilities of the products they develop (Patzelt et al., 2008; Dietz and Bozeman, 2005; Westphal and Milton, 2000). In high technology industries like biotechnology, the success of NPD projects often depends on inter-firm partnerships and strategic alliances with other players in the industry. These alliances can offer access to specialized knowledge needed to develop new products (Rothaermel and Deeds, 2006; Oliver and Liebeskind, 1998; Deeds and Hill, 1996; Powell et al., 1996). Further, biotechnological firms often enter into alliances with incumbent firms to access their production, distribution, and marketing capabilities (Rothaermel and Deeds, 2004; Baum et al., 2000; Lerner and Merges, 1998). With more industry experience and larger networks within an industry TMTs are more likely to find an appropriate alliance partner that offers, and is willing to share, the complementary capabilities they need to successfully complete NPD processes.

In sum, before an NPD failure industry experience signals to investors that TMTs have both the sector specific knowledge and networks to successfully complete the NPD process, raising investors expectations of successful NPD. Thus,

*Hypothesis 1c: When NPD projects fail, the more industry experience a firm's TMT has the larger the decrease in market value.*

Hypotheses 1a-c propose that the decline in firm value after NPD failures increases with increasing levels of financial, innovation, and managerial capabilities because these capabilities raise investors' expectations of NPD success

before the failure. An alternative perspective, however, suggests that in case of NPD failures the decline in firm market value is less determined by investors' ex ante expectations, but more by their ex post expectations that the firm will successfully recover from failure (De Carolis et al., 2009; Morrow et al., 2007; Tan and Peng, 2003; Cheng and Kesner, 1997). That is, a firm's financial, innovation, and managerial capabilities can indicate its potential to re-gain and/or maintain competitive advantage after the failure of a NPD project.

**Investors' ex post expectations and NPD failure**

*Financial capabilities* provide the slack necessary to effectively recover from NPD failures and increase the strategic options the firm has available to advance and/or refill its existing product development pipeline (Campart and Pfister, 2007; Guedj and Scharfstein, 2004). Firms can compensate for the loss of a new product candidate by enhancing their in-house development efforts of other projects they pursue. Allocating additional financial capabilities to these projects speeds up their development. For example, financial capabilities may be used to hire additional, highly qualified researchers and buy new devices, which may contribute to move a pre-clinical drug candidate into clinical development more quickly, thus compensating for the failed product. Further, firms can use financial capabilities to refill their product development pipeline by in-licensing new product candidates and buying intellectual property from other firms, universities, or research institutes (Kasch and Dowling, 2008; George, 2005). Finally, in order to compensate for NPD failures, firms can develop new product candidates by allying with other organizations and pursuing joint NPD projects (Badir et al., 2009; Baum et al.,

2000). Sufficient financial capabilities guarantee that firms pursuing this recovery path will be in a strong negotiation position and maintain control over the jointly developed product (Rothaermel and Deeds, 2004; Lerner and Merges, 1998). Financial slack leading to strategic flexibility to choose between alternative recovery paths (or pursue several of them in parallel) provides a strong signal to investors particularly in times of hostile equity markets since it indicates that firms can refill and advance their NPD pipeline without raising additional capital (Denis and Sibilkov, 2010; Xu, 2009). Thus,

*Hypothesis 2a: When NPD projects fail, the more cash available to a firm the smaller the decrease in market value.*

*Innovation capabilities* facilitate recovery from NPD failures because they allow firms to generate new, and capitalize on, existing knowledge in order to quickly develop new product candidates compensating for the loss experienced. For example, firms with high R&D intensity can create new knowledge by pursuing several internal research projects in parallel. This increases the probability that at least one of these projects will successfully complete the research stage and yield a prototype that they can move forward into advanced stages (Levitas and McFadyen, 2009; Xu et al., 2007). Further, high R&D intensity indicates to investors that firms have a substantial stock of existing knowledge. With a growing stock of existing knowledge the firm's absorptive capacity – their ability to identify and acquire knowledge from partners as well as understand and apply this knowledge for its own use – also increases (Zahra and George, 2002; Cohen and Levinthal, 1990). Increased absorptive capacity facilitates the use of strategic

alliances to fill the gap in the firm's research pipeline. For example, after NPD failure firms can enter into strategic alliances with universities (Rothaermel and Deeds, 2006; Oliver and Liebeskind, 1998; Powell et al., 1996) or other firms (Rothaermel and Deeds, 2004; George et al., 2002) to acquire the knowledge they need to develop new product candidates and prototypes. In contrast, low R&D intensity indicates to investors that the firm's product pipeline is drying out after NPD failure and that there are only limited opportunities to establish partnership that help to re-fill the product pipeline (Levitas and McFadyen, 2009; Girotra et al., 2007). Thus,

*Hypothesis 2b: When NPD projects fail, the higher the R&D intensity of a firm the smaller the decrease in market value.*

*Managerial capabilities*, defined as the TMT's industry experience, can also provide a strong signal to investors that firms can recover from NPD failure because knowledge of, and networks within, an industry facilitate managers to deal with the challenges arising from failure. When seeking for new technologies and NPD opportunities compensating for the failed product candidate, managers with industry-specific knowledge can identify areas where no or only modest competition exists, and they can assess the threat of competitors' entry into these new technological fields. Knowledge of industry regulations allows managers to select those opportunities and technologies that comply with regulatory guidelines and patent laws, ensuring that the recovery process will not be delayed or even stopped by legal battles and patent infringements. Further, industry experience enables managers to successfully reorganize internal assets after NPD failure. For

example, in industries such as biotechnology where failures are frequent, routines and procedures may exists to redeploy capabilities and personnel to new NPD projects in the most efficient way (De Carolis et al., 2009; Himmelmann and Schiereck, 2009). Knowledge of these routines suggests to investors that managers reallocate the firm's assets in a way that the recovery process will be effective and efficient.

Second, industry-experienced managers can draw on a network of potential suppliers or alliance partners (Eisenhardt and Schoonhoven, 1996) to acquire the raw material, knowledge, and other capabilities needed to initiate new projects compensating for NPD failure. These managers can leverage their network contacts to identify intellectual property and new product candidates for filling up their development pipeline by in-licensing and collaborative NPD (Fischer and Pollock, 2004; Zhang and Rajagopalan, 2004). Knowledge of the industry's players will help to identify those partners with the necessary goodwill for successful collaboration and counteract entering into unsuccessful alliances with opportunistic partners (Kor and Misangyi, 2008). Thus,

*Hypothesis 2c: When NPD projects fail, the more industry experience a firm's TMT has the smaller the decrease in market value.*

**The moderating role of product development stage**

Our arguments suggest that increasing levels of organizational capabilities may either increase or decrease the loss of market value firms experience in case of NPD failures. While a number of factors may explain which perspective prevails

when, in our model we propose that the development stage of the failed product is a particularly likely candidate for this explanation.

First, the more advanced a product under development, the more likely it will successfully complete the NPD process, reach market launch, and create returns for firms and investors. Advanced products have already passed all the critical stages during early development phases where they could have failed. The likelihood of failure in these early stages can be substantial. For example, in the biotechnology industry, for every 5,000 compounds that emerge from drug discovery only five compounds pass the research stage (Evans and Varaiya, 2003, Stewart et al., 2001), and even after entering the development stage the accumulated probability of failure for pre-clinical and clinical development stages is about 80 % (Moran, 2003; DiMasi et al, 2003). In contrast, only 20 to 40 % of drugs that have already entered into late Phase III clinical development do not reach market launch (Himmelmann and Schiereck, 2009; Kellogg and Charnes, 2000). Advanced development stages therefore indicate to investors that returns are relatively certain and near in time. Before late stage failures investors will strongly value a firm depending on its capabilities to successfully complete the final steps of the NPD process and generate high returns from the new product in the future. Thus, if the product candidate fails investors' ex ante expectations of successful NPD will mainly determine their reactions to NPD failures.

In contrast, due to the many uncertainties and intrinsically high failure rates of early stage product candidates, before the failure investors are less likely to substantially value a firm by its abilities to successfully introduce these products to

market. In case of early stage products, investors expect failure as the most likely outcome of NPD. They are therefore more concerned about whether the firm has the necessary capabilities to compensate for the (highly likely) loss of these new product candidates and continuously re-fill their NPD pipeline by in-house innovation and research. These investors view NPD failures more from an ex post perspective and a firm's ability to recover quickly from failures.

Second, the more advanced a new product candidate, the more capability-intensive the development becomes, and the more specialized the assets the firm needs to continue the NPD process. For example, in the biotechnology industry average expenditures of early Phase I clinical testing are about $57 million whereas they amount to $418 million for late Phase III clinical testing (Girotra et al., 2007). Further, in later development stages facilities for mass production, distribution channels, and marketing capabilities specific for the new product need to be developed. Although the development of these specialized assets is often very costly, they can not (or not fully) be used for the development of other product candidates. That is, new product candidates in later development bind a more substantial fraction of the firm's financial, innovation, and managerial capabilities than product candidates in early stages. For example, in case of NPD failure the firm may need part of its financial capabilities to dissolve already established marketing alliances with other firms, patents filed may not apply to other research projects, and managers hired because of their marketing and production experience in the respective area may not be needed immediately after the product's failure. The more specialized the capabilities the firm has built up to advance a late stage

product candidate, the stronger the impact of these capabilities will be on investors' valuation of the firm before NPD failure (*ex ante* perspective).

In contrast, the development of early stage products requires less specialized assets (e.g., there is not yet a necessity to build up large scale production and marketing facilities or hire a marketing manager for the developed product). Most of the firm's financial, innovation, and managerial capabilities can be allocated to alternative projects after early stage NPD failure to compensate for the lost product candidate. The higher the level of these non-specialized capabilities, the more investors will focus on the firm's ability to recover from the failure (*ex post* perspective).

In sum, the later the development stage of a new product candidate, the more the market value of a firm depends on its financial, innovation, and managerial capabilities needed for successful market introduction of that product. The product-specificity of these capabilities increases with the product's development stage. In case of late stage NPD failures, the decline of firm market value therefore depends more on a firm's capabilities for making the product successful (*ex ante* perspective), whereas for early stage failures the role of financial, innovation, and managerial capabilities for successful recovery from failure appears more influential (*ex post* perspective). Thus,

*Hypothesis 3a: When NPD projects fail, the interaction between the development stage of the failed product candidate and the firm's cash position is negative and thus increases the decline in firm market value.*

*Hypothesis 3b: When NPD projects fail, the interaction between the development stage of the failed product candidate and the firm's R&D intensity is negative and thus increases the decline in firm market value.*

*Hypothesis 3c: When NPD projects fail, the interaction between the development stage of the failed product candidate and the firm's TMT industry experience is negative and thus increases the decline in firm market value.*

## 2.3 Methodology

### *2.3.1 Sample and data collection*

To test our hypotheses we chose the biotechnology industry in the US as a sampling frame and focused on firms commercializing new drugs for the treatment of human diseases. This sector is well suited for our analysis because it is a relatively young, knowledge and invention intensive industry where highly risky new product development is critical for firm success (De Carolis et al., 2009; Girotra et al., 2007; De Carolis and Deeds, 1999). Furthermore, the development process for new drugs is well defined, such that failures in this process and NPD stages can be well determined (Sarkar and de Jong, 2006; Evans and Varaiya, 2003). After each of these development stage firms must decide whether to continue with the next stage or to terminate development (Abrantes-Metz et al., 2005; Guedj and Scharfstein, 2004).

Our sample consists of publicly traded biotechnology firms that were listed on the NASDAQ Biotechnology Index during the period 1994 to 2008. We

explicitly focus on NPD failures that occurred during the clinical development stages and the FDA approval phase since (i) announcement of these failures must be published due to SEC disclosure requirements, and (ii) the impact of these failures on firm value is more substantial than, for example, failures in the research or pre-clinical development stages. Clinical trial data was collected from the Recombinant Capital Database (ReCap), a database of biotechnology firm press releases that has been widely used for empirical studies in this field before (De Carolis et al. 2009; Rzakhanov, 2004). Additionally, financial data, data on the top management team, and other data was gathered from The Wall Street Journal, MarketWatch, LexisNexis, and the companies' annual reports and web pages.

Our initially identified sample consisted of 92 biotechnological firms which experienced 593 NPD failures at clinical trial stages between 1994 and 2008. A total of 306 NPD failures were dropped from the sample because full information of the exact failure date or the failed product's development stage was not available. Moreover, 87 NPD failures were excluded because firm financial data at the time of the failure date were not available. Importantly, personal communication with ReCap employees yielded that NPD failures which were listed in the data base as having occurred on the first day of a month may indicate failures for which only the month, but not the accurate day, could be correctly identified by ReCap. Therefore, we crosschecked all failure dates with the firms' press releases and SEC filings leading to an additional drop of 34 data points for which such cross-validation was not successful. Thus, our final data set consists of 166 clinical

new product failures from 70 biotechnology firms. At the time of NPD failure, firms were, on average, 15 years old and had about 1,440 employees.

### *2.3.2 Measures*

*Dependent variable.* The dependent variable in our study, Cumulative Abnormal Return (CAR), captures the financial impact NPD failures have on valuation of biotechnology firms (Girotra et al., 2007; McWilliams and Siegel, 1997). Following previous research on event study methodology (Brown and Warner, 1985) we control for potentially confounding, firm-specific events by choosing a comparatively small event window around the exact date of the NPD failure. Further, in order to control for confounding industry-wide events we use the NASDAQ Biotechnology Index as the basis for calculating market-adjusted abnormal returns (Hendricks and Singhal, 2008; Campart and Pfister, 2007). We measure the CAR as the relative difference between the price of the benchmark index and the firm stock price during a three-day event window (Farber and Hallock, 2009; Mc Williams and Siegel, 1997) including the day prior to, the day of, and the day following the announcement of the NPD failure (CAR(-1,+1)). Event windows are defined with respect to trading days in the US at the NASDAQ. To check the robustness of our results, we also calculated different event windows (using CAR(0,+1) and CAR(-2,+2)). Our results remain stable for all these event windows (see also below).

The mean CAR(-1,+1) is -14.5%, indicating that during this period the average firm's market value decreased by 14.5% relative to the benchmark index. We found similar results for CAR(-1, 0) (-13.6%) and CAR(-2, +2) (-15.0%),

respectively, indicating that the market reaction to NPD failures is strongly negative in our sample. This is consistent with previous findings by De Carolis et al. (2009) and Girotra et al. (2007).

*Independent variables.* First, Cash represents the firms' financial capabilities and was taken from the 10-K SEC fillings and the annual reports in the period from before the NPD failure. Since in our data cash is strongly correlated with firm size, we follow others (Beatty, 1995) and use the firm size corrected ratio of cash and divide cash by the total number of employees.

Second, to measure firms' innovation capabilities we use R&D intensity, operationalized as a firm's R&D expenses per employee (Sher and Yang, 2005; Baysinger et al., 1991; Graves, 1988). This measure of innovation capabilities is consistent with Scherer (1984) who argues that R&D intensity is the best proxy for firm innovation. Importantly, another often used proxy for R&D intensity, R&D per sales (Long and Ravenscraft, 1993; Cohen and Klepper, 1992), is not defined for zero revenues. Since many young biotechnological firms in our sample do not earn any revenues due to the long NPD cycles, using this measure would lead to substantial sample selection bias. For our data, using the R&D per revenue measure and excluding those firms with no revenues and a single extreme outlier with 3,755 million $US R&D expenses per $US sales revenues leads to similar results as the analysis reported below based on R&D per employees using the full dataset.

Third, with respect to firms' managerial capabilities, we followed Zhang and Wiersema (2009) and Carpenter et al. (2004) and captured the years of industry experience of the firms' top managers as reported one period before the NPD

failure. This variable was labeled TMT experience. All data was validated by cross checking with the firms' 14-A SEC fillings and consolidated balance sheets.

Fourth, to simplify analysis we consider only two product development stages. Average CARs are -5.1% for clinical Phase I failures, -8.9% for clinical Phase II failures, -21.6% for clinical Phase III failures, and -24.6% for failures in the NDA approval phase. CARs for clinical phases I and II do not differ significantly (t-test with a t-value =1.12, df=88, p=0.27), and CARs for clinical Phase III and NDA approval phase do not differ significantly (t-value =0.37, df=74, p=0.71). However, CARs for clinical Phases II and III differ significantly (t-value =3.11, df=125, $p<0.001$). We therefore consider Phase I and Phase II as 'early stage' and Phase III and the NDA approval phase as 'late stage'. Stage is contrast coded with a value of -0.5 when the NPD failure occurred in early stage, and +0.5 otherwise. Our final sample consists of 90 early stage and 76 late stage failures.

*Control variables.* We include five control variables in our analysis known or expected to influence firm CAR. The first three relate to firm characteristics. First, we control for firm age since investors may assess the product failure risk of younger ventures higher due to their capability constraints (Zheng et al., 2010; Deeds and Hill, 1996). Firm age is operationalized as the number of days from firm inception to the NPD failure (De Carolis et al., 2009). Second, we control for firm size by including the total numbers of employees. Guedj and Scharfstein (2004) show that firm size signals better opportunities to access and control capabilities, suggesting that larger firms might generally have a better capability to buffer the impact of NPD failures. Third, we controlled for firm performance measured by

asset turnover (McGowan, 2007) defined as the ratio of sales to total assets, which we obtained from the annual reports for the fiscal year prior to the NPD failure announcement.

The last two control variables refer to demographic characteristic of the top management team. We control for TMT size (measured by the number of TMT members) since larger TMTs may be superior to smaller TMTs because they have more cognitive capabilities and social capital enabling them to better deal with complex decision tasks (Haleblian and Finkelstein, 1993). With respect to TMT age, older management teams are more likely to prefer established routines that have worked well in the past (Marcel, 2009), and they are less open to new ideas (Wiersema and Bantel, 1992). This suggests that they might be less willing to change a firm's strategic orientation after NPD failure and thus counteract an effective recovery process. We measure TMT age as the mean age of all those executives that constitute the TMT (Cohen and Dean, 2005; Herrmann and Datta, 2005).

## 2.4 Results

### *2.4.1 Descriptive statistics and correlations*

Descriptive statistics and correlations for the variables in our analysis are reported in Table 1. There are moderate correlations between firm size and TMT size, firm size and firm age, and firm size and asset turnover. This is not surprising since larger firms tend to have more TMT members (Carpenter et al., 2004; Wiersema and Bantel, 1992) and perform better (Lin et al., 2008; Huselid, 1995).

The moderate positive correlation between TMT age and TMT experience is also expected since older managers tend to have more experience. The negative correlation between R&D intensity and prior firm performance is consistent with De Carolis et al. (2009) and Huang et al. (2009). To ensure that these moderate correlations are no problem in our data set, we calculated variance inflation factors (VIFs) for a test of multicollinearity. All VIFs were below 2, which is far below 10 representing an accepted threshold level for tests of non-multicollinearity (Hair et al., 2005, Rothaermel and Deeds, 2006). Thus, none of the correlations in our dataset is high enough to justify concerns about multicollinearity.

| | **Mean** | **S.D.** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 CAR(-1,+1) | -14.48 | 0.23 | 1 | | | | | | | | |
| 2 Firm age | 14.88 | 5.39 | 0.08 | 1 | | | | | | | |
| 3 Firm size | 1.44 | 3.17 | 0.23** | 0.38*** | 1 | | | | | | |
| 4 Asset turnover | 0.23 | 0.21 | 0.24** | 0.16* | 0.37*** | 1 | | | | | |
| 5 TMT size | 6.05 | 2.36 | 0.12 | 0.28*** | 0.50*** | 0.22** | 1 | | | | |
| 6 TMT age | 51.63 | 4.71 | -0.14 | 0.02 | -0.01 | 0.17* | -0.18* | 1 | | | |
| 7 Cash | 0.28 | 0.29 | -0.12 | -0.01 | -0.20* | -0.22** | -0.17* | -0.05 | 1 | | |
| 8 R&D intensity | 0.26 | 0.19 | -0.43*** | -0.13 | -0.24** | -0.44*** | -0.22** | 0.02 | 0.17* | 1 | |
| 9 TMT experience | 15.51 | 3.68 | -0.15 | 0.08 | -0.15* | 0.01 | -0.11 | 0.49*** | -0.01 | 0.01 | 1 |
| 10 Stage | -0.08 | 0.10 | -0.31*** | -0.11 | 0.01 | 0.04 | 0.02 | 0.08 | -0.14 | 0.07 | 0.07 |

N=166,
Significance levels: * p < 0.05, ** p <0.01, *** p <0.001

**Table 1: Descriptive statistics and Pearson correlation coefficients**

*2.4.2 Results of the events study analysis*

To test our hypotheses we perform hierarchical moderated regression analyses. Heteroscedasticity- and cluster-robust standard errors were calculated based on the Huber-White sandwich estimation procedure correcting for the clustered nature of the data (more than one NPD failure per firm). This procedure is especially appropriate if there are, as in our data, few observations per cluster compared to the sample size (Wooldridge, 2002). To compare nested models and, thus, to test whether the increase in explained variance (R-squared) from one model over the other is statistically significant, we use Wald-like tests.

| | Hierarchical regression analysis | | | | Alternative event windows | |
|---|---|---|---|---|---|---|
| Model | 1 | 2 | 3 | | 4 | 5 |
| Dependent Variable | CAR (-1,+1) | CAR (-1,+1) | CAR (-1,+1) | Eta² | CAR (-1,0) | CAR (-2,+2) |
| Constant | 0.26 (0.20) | 0.14 (0.19) | 0.04 (0.18) | | 0.06 (0.16) | -0.06 (0.18) |
| *Control variables* | | | | | | |
| Firm age | -0.00 (0.00) | -0.00 (0.00) | -0.00 (0.00) | .000 | -0.00 (0.00) | -0.00 (0.00) |
| Firm size (in 1,000 empl.) | 0.01 (0.01)* | 0.01 (0.01)* | 0.01 (0.00)+ | .032 | 0.01 (0.00)* | 0.01 (0.00)+ |
| Asset turnover | 0.25 (0.11)* | 0.08 (0.10) | 0.07 (0.10) | .005 | 0.10 (0.11) | 0.06 (0.10) |
| TMT size | -0.01 (0.01) | -0.01 (0.01) | -0.01 (0.01) | .003 | -0.01 (0.01) | -0.01 (0.01) |
| TMT age | -0.01 (0.00)** | -0.01 (0.00) | -0.00 (0.00) | .012 | -0.00 (0.00) | -0.00 (0.00) |
| *Main effects* | | | | | | |
| Cash | | -0.02 (0.01) | -0.04 (0.02)* | .038 | -0.04 (0.02)+ | -0.04 (0.02)* |
| R&D intensity | | -0.08 (0.02)*** | -0.08 (0.02)*** | .159 | -0.07 (0.02)** | -0.09 (0.02)*** |
| TMT experience | | -0.01 (0.02) | -0.03 (0.02) | .021 | -0.02 (0.02) | -0.03 (0.02) |
| Stage | | -0.07 (0.02)*** | -0.07 (0.02)*** | .181 | -0.07 (0.02)*** | -0.07 (0.02)*** |
| *Cross-level Interactions* | | | | | | |
| Cash x Stage | | | -0.04 (0.02)* | .042 | -0.04 (0.02)+ | -0.04 (0.02)* |
| R&D intensity x Stage | | | 0.01 (0.02) | .002 | -0.00 (0.02) | 0.01 (0.02) |
| TMT experience x Stage | | | -0.04 (0.02)* | .052 | -0.03 (0.02)* | -0.04 (0.02)* |
| Observations (clusters) | 166 (70) | 166 (70) | 166 (70) | | 166 (70) | 166 (70) |
| R-squared (F value) | 0.11 (7.53)*** | 0.31 (7.86)*** | 0.36 (8.83)*** | | 0.35 (7.31)*** | 0.37 (10.52)*** |
| Delta R-squared (F value) | | 0.20 (7.29)*** | 0.05 (3.93)* | | - | - |

**Note:** Heteroscedasticity- and cluster-robust standard errors reported in parentheses.
Eta² is reported as a measure of effect size.
Significance level: + p < 0.10, * p < 0.05, ** p <0.01, *** p <0.001 (two-tailed tests)

**Table 2: Hierarchical Moderated Regression Analysis (OLS)**

We first calculate the base model (Model 1), which includes only control variables. This model is statistically significant ($p < .001$) and explains 11.1% of the variance in CAR(-1,+1). Including the main effects (Model 2) yields a statistically significant model ($p < .001$) with an explained variance of 31.3%. This increase as compared to the base model is significant ($p < 0.001$). Finally, including the interaction effects (Model 3) yields a significant model ($p < .001$) explaining 35.9% of the variance in CAR(-1,+1). The increase of explained variance as compared to the main-effects only model is again significant ($p < 0.05$). Models 4 and 5 in Table 2 report the hierarchical regression for the full model for alternative event windows, CAR(-1,0) and CAR(-2,+2). All variables that are part of interactions were standardized, which allows us not only to compare the effects of different variables in the regression, but also to interpret the main effects as average effect of variables, averaged over all values of the moderating variable (Cohen et al., 2003).

Considering only the main effects (averaged over early- and late-stage failures), results in Model 2 indicate that firms with more cash and a higher level of R&D intensity are associated with larger drops in their stock prices ($\beta$cash/size = -0.04, $p<0.05$ and $\beta$R&D intensity = -0.08, $p<0.001$, respectively). These results support Hypotheses 1a and 1b, and reject the competing Hypotheses 2a and 2b, respectively. Since there is no significant relationship between CAR(-1,+1) and TMT experience, our results indicate no support for either of the competing main effect Hypotheses 1c and 2c.

Regarding proposed interaction effects we find statistically significant interactions between development stage and cash as well as between development stage and TMT experience (Model 3). The coefficient of the interactions is negative in both cases (βcash/size X Stage = -0.04, $p<0.05$ and βTMT exp. X Stage = -0.04, $p<0.05$), indicating that for later development stages cash and TMT experience have a less positive or more negative impact on CAR(-1,+1). The nature of these significant interactions supports Hypotheses 3a and 3c, respectively. Note that the insignificant main effect had indicated no or just a small effect of TMT experience, while the significant interaction effect indicates that TMT industry experience does have an effect. Further, we find no significant interaction effect between stage and R&D intensity. Thus, Hypothesis 3b is not supported.

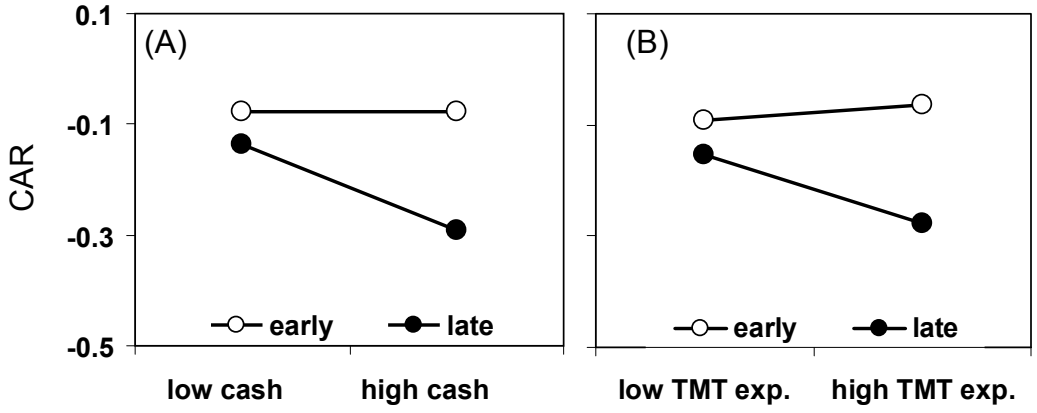


**Figure 5: Interaction effects of project development stage with (A) Cash, and (B) TMT industry experience**

**Source: Own illustration**

In order to better understand the significant interaction effects we visualize them in Figure 5. On the x-axis we plot cash (Figure 5A) and TMT experience (Figure 5B), respectively, while the y-axis represents CAR(-1,+1). We plot separate

lines for early and late stage failure. Figure 5A shows that the relationship between firms' cash and CAR is more negative when the firm experiences later stage failure than earlier stage failure. In fact, for early stage failures cash has little effect on CAR(-1,+1). This suggests that for late stage NPD failures, the decline in firm market value is mainly determined by investors' ex ante expectations, while in the case of early stage failures either investors balance ex ante and ex post perspectives, or they pay little attention to firm cash at all (note that the absolute CAR is relatively small for early stage failures). Figure 5B plots the relationship between TMT experience and CAR(-1,+1) for early and late stage NPD failures. While this relationship is negative for late stage failures, it is positive (though not significant) for early stages. This suggests that investors emphasize an ex ante perspective more in case of late stage failures, but put more emphasis on ex post perspectives and the role of a firms' TMT in recovery from failure in case of early stage failures. We will discuss these findings and their implications in more detail below.

Finally, it is important to note that we obtained similar results leading to the same conclusions when we regressed the variables of interest on the alternative event windows CAR(-1,0) and CAR(-2,+2), respectively. This indicates that our results are robust across different operationalizations of the dependent variable of our study.

**2.5 Discussion and conclusion**

New product development failure is a frequent phenomenon among high technology firms, yet how investors react to these failures is still poorly

understood. In this study, we combine ex ante and ex post perspectives to develop a model of investor reactions to NPD failures. Our data support such a combined perspective by demonstrating that the development stage of the failed project determines, partly, the extent to which investors emphasize either perspective. Specifically, we find that a significant interaction exists between product development stage and firms' financial capabilities, and between product development stage and firms' managerial capabilities. However, we do not find a significant interaction between development stage and innovation capabilities; it appears that more innovation capabilities have an overall negative effect on firm market value in case of NPD failures. These results have implications for NPD theory and managerial practice.

### *2.5.1 Implications for literature*

The new product development literature is surprisingly silent on the effect of project failure at different stages of development. For example, many existing studies only focus on firm-specific factors that influence investor reactions to NPD failure (De Carolis et al., 2009; Xu et al., 2007; Napshin and De Carolis, 2007; Sharma and Lacey, 2004), but neglect that products can fail at different development stages. Indeed, to the best of our knowledge, only three studies on NPD failure explicitly acknowledge heterogeneity in the development stages of new product candidates. First, Girotra et al. (2007) investigate NPD failures of phase III clinical trials of new drug candidates and explain variance in project valuation based on interactions of the failed product with other product candidates at different development stages in the firm's product pipeline. Second, Guedj and

Scharfstein (2004) find that when clinical phase II drug candidates advance to clinical phase III often agency problems between managers and investors arise. More recently, Himmelmann and Schiereck (2009) show that stock movements are more substantial when firms announce late stage product news than when they announce early stage product news, probably because investors are reluctant to R&D related uncertainty. Our finding that product development stages are important to consider when explaining the impact of firm capabilities on organizational consequences of NPD failure complements these studies and suggests that future NPD theory should more explicitly acknowledge heterogeneity in product development stages and the impact of this heterogeneity on organizational outcomes of (successful or unsuccessful) NPD processes.

Moreover, our study finds that, independent of the development stage of the failed product, firms with more R&D intensity suffer more from NPD failures than firms with low R&D intensity. While this finding is consistent with previous work taking an ex ante perspective on investor reactions to NPD outcomes (Guedj and Scharfstein, 2004), it challenges the argument that high R&D intensity facilitates a quick recovery from failure in the eyes of investors (ex-post perspective, De Carolis et al., 2009). This is somewhat surprising given that more R&D can trigger the development of new products (Rzakhanov, 2004). One explanation of our finding might be rooted in the long product development cycles of the biotech industry. Since today's R&D expenditures only lead to marketable products (or product candidates in late development stages) in the far future, high R&D intensity may insufficiently signal the firm's recovery potential on the short and medium

term, which might be more relevant for investors' ad hoc reactions to NPD failures. In industries with shorter NPD cycles, a firm's actual R&D intensity may therefore contribute more to investor's assessments of its recovery potential. Future research can test this assumption by focusing on sectors like software and electronics.

Our study adds to Upper Echelon research (Hambrick and Mason, 1984) by investigating the role of the top management team in the context of adverse events such as NPD failures. While many Upper Echelon studies have focused on how TMTs impact the financial performance of firms over an extended time frame (Jensen and Zajac, 2004; Boeker, 1997), much less is know about TMTs' role in case of adverse events. Recently, Napshin and De Carolis (2007) proposed that the composition of a firm's TMT is critical to investor perceptions of adverse events. Using a dataset of 84 clinical trial terminations of biotechnological firms they show that TMT age decreases investors' perceptions of event severity, suggesting that investors judge more experience (as indicated by age) as facilitating recovery from failures (consistent with the ex post perspective). Other studies (Jain et al., 2008; Certo, 2003) suggest that more industry experienced top management boards signal toward investors the knowledge and ability to change the firm's strategic direction in critical situations. Importantly, however, these authors do not investigate if (and how) this effect is contingent on the nature of the adverse event. Our approach suggests that in some cases (late stage failures) investor expectations that industry experienced TMTs conduct successful NPD are more important than their judgment of the TMT's ability to recover from NPD failures. It appears that a fine-

grained approach and a contingency perspective are necessary to understand in detail how TMTs impact firm performance in the case of adverse events.

Existing research on the antecedents and outcomes of innovation processes generally focuses on only one level of analysis while neglecting heterogeneity at other levels of analysis (Rothaermel and Hess, 2007). Focusing on only one level of analysis implicitly assumes that most of the existing heterogeneity can be found at the chosen level. Moreover, concentrating on this one level of analysis implies that the focal level of analysis seems to be more or less independent from interactions with other levels. In line with Rothaermel and Hess (2007) we thus propose a multilevel theoretical approach combining product-level and organizational-level effects. Our finding that organizational-level factors can mitigate the negative outcomes of NPD failure depending on the level of the product under development highlights the need to consider cross-level effects in the analysis of organizational outcomes of innovation processes.

More generally, our results are consistent with the capabilities-based view of the firm (Eisenhardt and Martin 2000; Teece et al., 1997) suggesting that firms are heterogeneous with respect to their idiosyncratic bundles of capabilities influencing performance. Our findings emphasize the "bundle" effect, that is, interdependencies of capabilities (financial, innovation, management) are valued by investors when one particular capability (a product under development) is lost. Variance in the nature of the lost capability (the product development stage) determines the value of other capabilities for future performance (as judged by investors). Moreover, our study adds to the emerging literature demonstrating that

more capabilities are not necessarily better for the firm under all circumstances. For example, scholars have shown that there is a curvilinear relationship between an organization's financial slack and performance because managers tend to deploy too much money inefficiently (Leonard-Barton, 1992). Our findings indicate that although sufficient and appropriate capabilities are doubtlessly needed to successfully completing NPD processes (Arikan and Mc Gahan, 2009; Evans and Varaiya, 2003), high levels of capabilities can enhance investors' expectations about positive NPD outcomes and thus increase their negative reactions to NPD failures. It appears that succeeding in NPD and not suffering too much from NPD failures are two sides of the same performance coin.

### *2.5.2 Implications for practice*

Our findings have implications for practice, especially for managers of high technology firms since they allow them to better anticipate and understand the financial consequences of potential NPD failures. Our result highlight the influence that investors' perceptions of the financial, innovative and managerial capabilities of the firm have on value destruction after NPD failures, and how this influence is dependent on the development stage of the failed product. Based on the success probabilities managers attribute to their new product candidates, they might align development stages of new product candidates with their organization's capabilities in terms of cash, R&D intensity and industry experience of the top management team. For example, managers who believe that their late stage new product candidate still has a relatively high probability of failure can buffer against potential negative consequences of failure by trying to out-license the new product

candidate for further development, particularly when their firm is in a strong cash position and their TMT is highly experienced. Managers should be aware that signaling firm-specific capabilities to investors can influence investor expectations and preserve shareholder value in case of NPD failures, but is contingent on the firm's product portfolio (De Carolis et al., 2009; Girotra et al., 2007).

### *2.5.3 Limitations and future research*

As all studies, this one has limitations which in turn provide opportunities for future research. The first limitation is that we focus only on biotechnological companies, and thus on a single high technology industry. While this sampling technique rules out methodological threats such as potential confounding effects (Zheng et al., 2010), it raises the question of generalizability to a larger population. Caution must be exercised when transferring findings from a single industry to others, for example an industry with shorter NPD cycles (as outlined in the discussion). We hope that future research will test whether our findings are robust in settings other than the US biotechnology industry.

Further, it is important to note that our study provides only a snap-shot of investors' reactions to failure events, but it does not investigate which firms recover from the failure event and which ones do not. While we show that the availability of capabilities at the time of failure impacts the investors' judgment of the firm's future perspectives (as reflected in its stock price), an effective deployment of these capabilities in the time period following the failure is important for recovery. For example, on a mid-term horizon (e.g., several months) financial, innovation, and managerial capabilities might have different effects on investor judgments than at

the immediate time of failure. Future studies can investigate the recovery paths of firms after the failure of a new product candidate has been announced.

In conclusion, our study investigates how investors react to NPD failures and the role of firm-specific capabilities and the development stage of the failed product in these reactions. While high levels of financial and managerial capabilities can buffer the decline in firm value after failure of early stage products, these capabilities might also raise investor expectations of successful NPD for late stage product candidates leading to an increased negative stock return. These findings extend existing NPD literature by demonstrating that the impact firm-specific capabilities have on investor reactions to NPD outcomes depend on the development stage of the project. The results emphasize the complexity of investor reactions to NPD failures and the interdependencies between product-level and organizational-level factors in explaining these reactions.

# 3 The role of top management in dealing with new product development failures in high technology firms[2]

According to strategic management literature the negative effect of new product development failures on firm market value can be enhanced or diminished by organizational variables specific to a company (De Carolis et al., 2009; Girotra et al. 2007). Combining resource based arguments (Barney et al., 2001) with the Upper Echelon perspective (Hambrick and Mason, 1984) I show that high levels of firm R&D intensity enhance the negative valuation effect while high firm revenues diminish it. Moreover, my data finds that top management team industry experience moderates both effects, while TMT tenure has no significant influence. In Section 3.1 I introduce the topic. Then I review resource based theory in concert with the Upper Echelon literature and derive hypotheses in Section 3.2. The event study methodology used is explained in Section 3.3 and in Section 3.4 the results of the study are presented. In the final Section 3.5, I discuss theoretical implications for the NPD and Upper Echelon literatures and point out implications of the study including limitations and the potential for future research.

[2] This section is based on Buerger (2010) and has been accepted for presentation in a refereed Paper Session at the Babson College Entrepreneurship Research Conference, June 9-12, 2010, in Lausanne, Switzerland.

## 3.1 Introduction

The impact of new product development outcomes on firm performance is widely investigated (e.g. Hong and Roh, 2009; Hendricks and Singhal, 2008; Verona, 1999). However, only few studies focus on how NPD outcomes are linked to firm market valuation and stock market response (De Carolis et al., 2009; Girotra et al., 2007; Sharma and Lacey, 2004). Although NPD processes are typically associated with high failure rates (Sarkar and de Jong, 2006; Rzakhanov, 2004), empirical studies investigating negative NPD outcomes and the financial consequences are rare. Furthermore, existing studies neglect the role of the firms' management in dealing with NPD failures. This is surprising given that the top management team is crucial for firm performance (Cannella et al., 2008; Dimov and Shepherd, 2005; Michel and Hambrick, 1992) and investors assessments of firms' future potential (Napshin and De Carolis, 2007; Kintu, 2002).

Existing studies show that after NPD failures firm specific resources can mitigate the negative effects on firm market values (Buerger et al., 2010; De Carolis et al., 2009; Sharma and Lacey, 2004). Further, leadership affects firm performance and market value (Zhang and Wiersema, 2009; Shen and Cannella, 2002). Combining these findings, this study argues that the effective usage and deployment of firm resources required for recovering from NPD failure is contingent on the experiences of the firm's TMT, specifically TMT industry experience and company specific experience (TMT tenure). I focus on NPD failures occurring during late development stages since these are known to result in substantial drops in firm stock prices due to (i) the huge resource commitments

made (Girotra et al. 2007); and (ii) disappointed investors' expectations because NPD failures destroy firm's future potential (Himmelmann and Schiereck, 2009; Sharma and Lacey, 2004).

My model is tested on data on 77 biotechnological NPD failures of publicly traded biotechnology firms during the period 1994 to 2008. Using an event study technique, I show that firm revenues can buffer the effect of NPD failures on firm market valuation while, in contrast, firm R&D intensity can foster this valuation effect. Moreover, both valuation effects are positively moderated by managerial experience. Specifically, I find that TMT industry experience enhances the buffering effect and mitigates the enhancing effect of firm resources. Interestingly, however, my data do not show any effect of managerial tenure in buffering NPD failures. It appears that managerial knowledge and networks that go beyond organizational boundaries are more important to recover from NPD failures than knowledge and networks that are firm specific.

This study contributes to existing NPD literature in three ways. First, by considering managerial and organizational resources interdependently, I provide a more complete picture of NPD failures than studies that focus only on direct effects of firm resources, and that neglect the role of TMTs in allocating firm resources effectively for recovering from NPD failure (De Carolis et al., 2009; Girotra et al., 2007). Second, since managerial experience explains a significant share of variance in the impact of NPD failures on firm market values, this highlights the relevance of managerial resources for explaining market reactions to negative NPD outcomes. With respect to future research on the role of managerial experience in high

technology firms, my results highlight the importance of distinguishing between industry and firm specific TMT experience. Both types appear to be relevant for accomplishing different organizational tasks. Finally, this study has implications for managers of high technology firms since it allow them to better anticipate the financial consequences of potential NPD failures. Specifically, my results highlight the influence that investors' perceptions of organizational and managerial resources have on firm market values in this context.

The paper proceeds as follows. In the second section, the conceptual background for the model is presented and hypotheses are derived. Next, I describe the research methodology and the empirical results. Finally, in the fourth and final section, I review the outcomes and implication of the study, including limitations and new avenues for future research.

### 3.2 Theory development

In dynamic and uncertain environments new product development is typically characterized by high failure risk (De Carolis et al., 2009; Guedj and Scharfstein, 2004; Teece et al., 1997; Dess and Beard, 1984). This is especially true for high technology firms that typically face resource constraints and lack developed routines (Stichcombe, 1965). Further, the visibility of NPD outcomes significantly impacts investor perceptions and, consequently, firm market values (Himmelmann and Schiereck, 2009; Girotra et al., 2007; Sharma and Lacey, 2004). Since firms are heterogeneous with respect to resource endowments that are essential in building up competitive advantages (Wernerfelt, 1984), firm specific resources signal firms' future potential to investors.

As noted by Ocasio (1997), however, firms may experience adverse events when, contrary to investor expectations, major strategic goals are not met. These adverse events, such as NPD failures, deteriorate the perceived value-creating capacity of the firm. Moreover, NPD failures lead to increased information asymmetry between firm managers and investors (Sharma and Lacey, 2004) and provide negative signals to investors since they expect decreased future cash flows and performance (Buerger et al., 2010; De Carolis et al., 2009). Girotra et al. (2007) demonstrate that this is especially true for the case of late stage NPD failure due to large resource investments that have been made. Recent studies show that NPD failures happening during late stages result in disappointed expectations by investors leading to significant drops in firm market values (Himmelmann and Schiereck, 2009; Girotra et al., 2007; Rzakhanov, 2004).

Building on resource based theory I propose that the availability of firm specific resources will act as credible signal for investors regarding the firms' ability to successfully recover from NPD failure. This will, in turn, influence the financial consequences NPD failure has on firm market values. Consistent with prior work (Zhang and Wiersema, 2009; De Carolis et al. 2009; Buerger et al., 2010; Guedj and Scharfstein, 2005; Rzakhanov, 2004), I explicitly focus on firm specific resources shown to significantly impact firm valuation and performance: firm R&D intensity and firm revenues. I will complement these variables by addressing the moderating effects of TMT industry experience and TMT tenure.

*Firm R&D intensity.* R&D investments reflect the firm's intangible assets such as the ability to transform internal knowledge into new marketable products

(Xu et al., 2007). These future benefits, however, are uncertain (Helfat and Peteraf, 2003). However, R&D investments enable firms to exploit new knowledge and foster parallel development strategies with different projects simultaneously (Girotra et al., 2007). This flexibility can positively impact firm performance given that the firm allocates these investments such that the product pipeline optimally balances long development cycles and low success rates (Rzakhanov, 2004).

Studies on the innovative competency of firms (De Carolis et al., 2009; Cohen and Klepper, 1992; Hill and Snell, 1988) use firm R&D intensity as a proxy describing how much firms invest into R&D relative to its size or revenues. More funds committed to R&D enhance the chances that a firm has to bring innovative products to market (Xu et al., 2007). High R&D intensity signals to investors that the firm invests comparatively more of its resources into R&D projects and that it will bring only the most promising NPD candidates to the next development stage. Consequently, as NPD projects reach later stages, investors will raise higher expectations for these candidates to successfully complete the development process (Himmelmann and Schiereck, 2009; Rzakhanov, 2004). When NPD projects fail during later stages, investors may interpret high R&D intensity as inefficient resource allocation since they expect that high R&D intensive companies will push forward only the best NPD projects. In contrast, NPD failure by firms with low R&D intensity may suffer less market devaluation when they experience NPD failures since investors a priori expectation is lower. Thus,

*H1: The higher the R&D intensity of a firm the greater the decrease in market value after NPD failure.*

*Firm revenues.* Firm performance is associated with substantially higher firm revenues (Medoff and Abraham, 1980), and firms generating more revenues tend to achieve greater market values (Chandra and Ro, 2008). High firm revenues can act as positive signal to investors that a firm is able to capture much of its products' values (Jegadeesh and Livnat, 2006). Investors will expect that firms currently generating high firm revenues are able to generate high revenues in the future based on the product candidates they currently develop (Guedj and Scharfstein, 2004). Indeed, recent observations by Xu and Cai (2009) demonstrate that firm revenues are the most relevant information for firm market valuation, even more than traditional measures such as earnings and cash flow.

I propose that high firm revenues can buffer negative reactions of investors to NPD failures because revenues provide firms with the financial slack and strategic flexibility to re-fill the NPD pipeline. For example, revenues can be re-invested in new in-house R&D projects that yield new product candidates compensating for the loss experience. Further, if firms enter into R&D alliances with other organizations to re-fill their NPD pipeline, solid revenues provide the cash needed to be in a strong enough negotiation position to counteract opportunistic partner behaviour and appropriate much of the newly developed product's ownership (Lerner and Merges, 1998), even in times of hostile financing environments (Lerner et al., 2003). Thus,

*H2: The higher the revenues of a firm the smaller the decrease in market value after NPD failure.*

**The moderating effect of top management team experience**

A firm's top management team is broadly defined *"as all executives with title above the rank of vice president or serving on the firms' board of directors"* (Cannella et al., 2008: 773). The Upper Echelon perspective (Hambrick and Mason, 1984) claims that the TMT is authorized to make the decisions necessary for adapting the firm to environmental demands. The composition of the TMT influences its mental models and decision outcomes and thus is crucial for firm performance (Dimov and Shepherd, 2005; Zaccaro and Klimoski, 2001; Knight et al., 1999). Linking TMT composition to firm market values, prior studies show that TMT attributes influence investor valuation of high technology firms (Higgins and Gulati, 2006; Certo, 2003) since these characteristics signal to market to the quality of the firm's TMT (Zhang and Wiersema, 2009; Cohen and Dean, 2005).

Few studies investigate the effects that top managerial characteristics have on firm market valuation during adverse events (e.g., Napshin and De Carolis, 2007). Since the TMT decides how firm resources are deployed, I suggest that managerial attributes affect the impact of firm specific resources on market values when late stage NPD failures occur. While recent work by Zhang and Wiersema (2009) and Marcel (2009) highlight the role of TMT industry experience and TMT tenure, I propose that these types of experience will leverage the impact of firm R&D intensity and firm revenues.

*Industry-specific experience.* TMT industry experience *"embeds tacit knowledge of opportunities, threats, competitive conditions, technology, and regulations specific to an industry, as well as goodwill, with industry players such*

*as buyers and suppliers"* (Kor and Misangyi, 2008: 1346). Starting a business without industry experience significantly increases the mortality rate (Cooper et al., 1994; Bruederl and Schussler, 1992). Start-up firms show superior performance when its managers have more industry experience (Kor, 2003). Furthermore, TMT industry experience impacts firm performance since it serves as a critical source of industry-specific social capital (Kor and Misangyi, 2008; Certo et al., 2001; Boeker 1997).

When NPD projects fail, the negative effect of a firm's R&D efforts on market value likely depends on the industry experience of the top management. Industry-experienced top management might be able to develop projects in a way such that failures do not lead to a complete loss of invested R&D expenditures, but that R&D resources can be redeployed effectively. Based on a real options approach (Huchzermeier and Loch, 2001), managers might be able to allocate R&D resources such that they can be re-used in alternative ways and allocated to other projects if one project fails. This avoids overinvestment, which is an explicit target of real option management (Kogut and Kulatilaka, 2001). For example, the laboratory devices and the scientific knowledge and know-how of a company built up on previous R&D efforts may be usable for other current or future projects. Experience in a particular industry provides top managers with knowledge about potential synergies between NPD projects, such that if one project fails the R&D resources invested can be used to advance the other project. Industry experience of top managers may therefore signal to investors that the firm has either has invested less in or is able to get more out of its R&D investments into failed projects.

Furthermore, TMT industry experience can strengthen the positive effect that revenues have on the firms' market value after NPD failure. As compared to top managers who are new to an industry, those with industry experience can better utilize the revenues to recover from failures. For example, based on their knowledge of industry-specific competition, these top managers may pay particular attention to re-fill the NPD pipeline by choosing new product candidates that address attractive market niches and segments where competition is manageable but a large enough market potential exists. Further, industry-experienced top managers may be able to use the cash at hand to in-license new product candidates which they identify with the help of their industry network partners. Thus,

*H3a: The relationship between the R&D intensity of a firm and the decrease in market value after NPD failure becomes less negative as TMT industry experience increases.*

*H3b: The relationship between the revenues of a firm and the decrease in market value after NPD failure becomes more positive as TMT industry experience increases.*

*Firm-specific experience.* Upper Echelon literature suggests that firm-specific experience (executive tenure) is a proxy for the TMT's firm-specific knowledge, skills, and power which ultimately affects organizational performance (Zhang and Wiersema, 2009; Carpenter, 2002; Hambrick and Fukutomi, 1991). Existing studies link TMT tenure to strategic change (Wiersema and Bantel, 1992),

firm performance (Miller and Shamsie, 2001), and IPO failure risk (Fischer and Pollock, 2004).

TMT tenure appears of particular importance in case of major NPD failures since investors may perceive longer tenured TMTs as better able to deal with the complex decisions required to recover from such an adverse event (Cohen and Dean, 2005). Highly tenured top managers possess deeper knowledge of the developed routines and interpersonal relationships within the organization (Zhang and Rajagopalan, 2004). Thus, TMT tenure signals to investors that top managers can understand the unique features of the firm and its internal tools available (Zhang and Wiersema, 2009). Moreover, top managers working together for an extended time period are better able to develop working patters, routines, and relationships that allow them to be more effective in handling difficult decisions (Fischer and Pollock, 2004).

The firm-specific knowledge and intra-firm relationships of longer tenured top managers might buffer the negative effect of R&D intensity on firm valuation when NPD projects fail. Deeper knowledge of the firm-specific R&D routines and processes allows top managers to allocate R&D resources in a way that they can be used effectively even after one NPD project had failed. For example, the better top managers understand the R&D-related know-how of the firm, the more they can develop a product portfolio exploiting synergies by drawing on the same R&D resources. Moreover, more developed interpersonal relationship in the firm provide top managers with the possibility to re-organize work groups after project failure in a way that the new team members get along well and complement each other in

terms of their skills and knowledge. Finally, highly tenured top managers with established relationship within the firm are more likely to find support among employees and R&D personnel during the reorganization process following the failure.

With respect to firm revenues, greater TMT tenure can enhance the positive effect of revenues have on firm market value after NPD failure. Knowledge of firm-specific routines and resources allows top managers to deploy the revenues generated in a way that they optimally compensate for the failed product. For example, these knowledgeable top managers can use revenues to acquire new product candidates that optimally leverage the skills and knowledge of the firm's scientists. Further, well developed intra-firm networks can provide top managers with information about the firm's current state of research, thus enabling them to better judge new R&D project proposals and in-licensing opportunities for development that could compensate for the failed project. Thus,

*H4a: The relationship between the R&D intensity of a firm and the decrease in market value after NPD failure becomes less negative as TMT tenure increases.*

*H4b: The relationship between the revenues of a firm and the decrease in market value after NPD failure becomes more positive as TMT tenure increases.*

## 3.3 Methodology

### *3.3.1 Sampling*

To test my set of hypotheses I chose the American biotechnology industry as a research setting. This sector is well suited for my analysis because it is a relatively young, knowledge and innovation-driven industry where highly risky new product development is critical for firm success (Levitas and McFadyen, 2009; Girotra et al., 2007; Sharma and Lacey, 2004). Furthermore, the development process for new drugs is clearly defined, such that NPD failures can be well determined (Himmelmann and Schiereck, 2009; Girotra et al., 2007). The NPD process starts with basic research in the lab, followed by pre-clinical studies and three clinical stages to ensure both the safety and effectiveness of the new product candidate in human subjects. Finally, each new drug must complete the New Drug Application review process before the Food and Drug Administration may classifies it as "approvable" for the US market (Sarkar and de Jong, 2006). After each of these development stages firms must decide whether to continue with the next stage or to terminate development (Abrantes-Metz et al., 2005; Guedj and Scharfstein, 2004).

My sample consists of publicly traded biotechnology firms listed on the NASDAQ Biotechnology Index between 1994 and 2008. To ensure comparability of NPD failures I exclusively focus on late stage NPD failures as they are known to be most value relevant for investors (Himmelmann and Schiereck 2009; Girotra et al., 2007). Clinical trial data was collected from ReCap database that is commonly used for empirical studies in the NPD literature (De Carolis et al. 2009; Rzakhanov,

2004). Financial data was collected from The Wall Street Journal, MarketWatch, LexisNexis and company web pages.

My initial sample of 92 biotechnology firms experienced 593 NPD failures at clinical trial stages during between 1994 and 2008. A total of 306 NPD failures were dropped because full information of the exact failure date or the failed product's stage was not available. NPD failures listed in the ReCap database as having occurred on the first day of a month may indicate failures for which only the month, but not the accurate day, could correctly be identified by ReCap.[3] After cross-checking all failure dates with the companies' press releases and SEC filings, I had to drop 34 data points for which such cross-validation was not successful. Moreover, I had to exclude 87 failures from my dataset because financial data at the time of failure were not available. After eliminating these cases, I end up with 166 NPD failures. These have observed different abnormal returns of -5.1% for clinical phase I failures, -8.9% for clinical phase II failures, -21.6% for clinical phase III failures, and -24.6% for failures during the NDA filing phase. I find no significant difference between phases I and II (t-value 1.12, df=88 with p=0.27) and between phases III and IV (t-value 0.37, df=74 with p=0.71), but a significant difference between phases II and III (t-value 3.11, df=125, with $p<0.001$). Therefore, I consider phases I and II as 'early stage' and phases III and IV as 'late stage'. As the focus of this study is exclusively on late stage failures, I eliminate all 89 early stage failures. Thus, my final data set consists of 77 late stage failures

[3] Personal e-mail communication with ReCap employees.

experienced by 50 firms that match my criteria and for which I has sufficient data to test my hypotheses.

### *3.3.2 Measures*

*Dependent variable.* Drawing on McWilliams and Siegel (1997), the dependent variable in my study, Cumulative Abnormal Return, captures the financial impact of NPD failures on market valuation of biotechnology firms. I control for potentially confounding events by identifying the exact event date and the optimal length of the event window (Zhang and Wiersema, 2009; Brown and Warner, 1985). In order to ensure that I captured the exact event date, all observations identified in the ReCap database were double-checked using SEC fillings and news reports provided by LexisNexis. By doing so, the date of the earliest news release for every observation was identified.

In order to control for confounding industry-wide events, I follow Hendricks and Singhal (2008) and use the NASDAQ Biotechnology Index as benchmark for my study. I measure CAR based on market adjusted returns (Henderson, 1990) as the relative difference between the price of the index and firm stock price during a three-day event window (Girotra et al., 2007; Nixon et al., 2004; McWilliams and Siegel, 1997). While focussing on a three-day event window, (-1, +1), I include the day prior to, the day of, and the day following the NPD failure in my analysis. Nevertheless, I report different time frames for robustness checks, i.e. CAR (-1, 0) and CAR (-2, +2) showing that my results are robust. Whereas the mean CAR (-1, +1) in my event study is -21.9%, indicating that the average firm market value decreased by 21.9% relative to the NASDAQ

Biotechnology Index, I find similar results for CAR (-1, 0) (-21.3%) and CAR (-2, +2) (-22.5%). This finding is consistent with prior studies (Buerger et al., 2010; De Carolis et al., 2009; Girotra et al., 2007). Note that, all event windows are defined with respect to trading days in the United States.

*Independent variables.* I use four measures to represent the independent variables of my model. First, firm revenues were taken from the 10-K SEC fillings in the period before the NPD failure. Since firm revenues are strongly correlated with firm size, I include the size corrected ratio of revenues over firm size by dividing revenues by the number of employees (Datta et al., 2005; Arora et al., 2001). Second, I include firm R&D intensity. Due to strong correlation between R&D expenses and firm revenues, I cannot include the absolute level of R&D expenditures and measured R&D intensity as R&D expenses divided by the number of employees (Graves, 1998; Hill and Snell, 1988). Third, following previous studies (Zhang and Wiersema, 2009; Carpenter et al., 2004), I capture industry experience of the firms' top managers from the managers' CV's published in the companies 14-A SEC fillings one period before the NPD failure. Industry experience was measured in the cumulated years TMT members spent in the biotechnology industry. Fourth, following prior work by Williams et al. (2005) and Carpenter (2002), I calculate TMT tenure by the number of years TMT members had served in the firm's top management team.

*Control variables.* I include five control variables in my analysis known or expected to influence firm CAR. First, I control for firm age since younger ventures have higher failure risks due to their lack of legitimacy and organizational

constraints (Zheng et al., 2010; Deeds and Hill, 1996). Firm age is operationalized as the number of days from firm inception to NPD failure (De Carolis et al., 2009). Second, with respect to firm size, I include the numbers of employees since larger firm size signals better opportunities to access and control resources (Guedj and Scharfstein, 2004). Thus, the increase in available resources can buffer the impact of NPD failure since it allows firms to more quickly recover. Third, I control for the firms' current cash position. I operationalize firm cash as the sum of cash and all securities readily convertible to cash listed in the firm's balance sheet (Rothaermel and Hill, 2005). Since firm cash and firm size are correlated, I follow Rzakhanov (2004) and use a ratio of firms' cash divided by employees.

The last two control variables refer to demographic characteristic of the top management team, which strategic management literature shows as affecting organizational performance (Canella et al., 2008; Kilduff et al., 2000; Eisenhardt and Schoonhoven, 1990). Therefore, I control for TMT size (measured by the number of TMT members) since larger TMTs may be superior to smaller TMTs because they have more cognitive resources and social capital which facilitates dealing with complex decision tasks (Haleblian and Finkelstein, 1993) associated with recovery from failure. With respect to TMT age, older TMTs are more likely to prefer established routines that have worked well in the past (Marcel, 2009) and less open to new ideas (Wiersema and Bantel, 1992), which might counteract recovery from failure. Following Cohen and Dean (2005) I measure TMT age as the mean age of all top management members.

## 3.4 Results

### *3.4.1 Descriptive statistics and correlations*

Table 3 presents descriptive statistics for my sample and correlations between variables. At the time of failure, firms were approximately 14 years old and had about 1,446 employees. The average TMT consists of six TMT members, has a mean age of 52 years, and 4.6 years of managerial tenure and 15.8 years of industry experience. Further, the correlation table shows a moderate correlation between firm size and three variables (with $r>0.30$), TMT size, age, and firm revenues. These relationships are not surprising; Zhang and Wiersema (2009) show that larger firms tend to have more TMT members. Similarly, large firms are typically older than small firms and have greater revenues since they are more likely to have already developed and market a drug (Guedj and Scharfstein 2004). However, none of the correlations are high enough to justify concerns about multicollinearity since VIFs were below 3 (max of 2.83), which has been accepted for studies like ours (Rothaermel and Hess, 2007). Standardizing the variables, via mean-centering, allows interpreting the main effects as average effect of variables, averaged over all values of the moderating variable (Cohen et al., 2003). The normality of the residuals is examined statistically using three normality test: neither the Shapiro-Wilk, Shapiro-Francia, nor the Skewness-Kurtosis tests could not reject the null hypothesis of normality of residuals.

| | Mean | S.D. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 CAR (-1,+1) | -0.22 | 0.28 | 1 | | | | | | | | |
| 2 Firm age | 14.29 | 5.410 | 0.04 | 1 | | | | | | | |
| 3 Firm size (1,000 empl.) | 1.446 | 3.377 | 0.27* | 0.46*** | 1 | | | | | | |
| 4 Cash / Firm size | 0.233 | 0.216 | -0.29** | 0.02 | -0.23* | 1 | | | | | |
| 5 TMT size | 6.143 | 2.275 | 0.13 | 0.35** | 0.35** | -0.17 | 1 | | | | |
| 6 TMT age | 52.01 | 4.749 | -0.11 | 0.06 | 0.08 | -0.07 | -0.16 | 1 | | | |
| 7 Revenue / Firm size | 0.238 | 0.280 | 0.25* | 0.09 | 0.49*** | -0.04 | 0.21 | 0.08 | 1 | | |
| 8 R&D intensity | 0.270 | 0.230 | -0.39*** | -0.15 | -0.22 | 0.26* | -0.20 | -0.14 | -0.28* | 1 | |
| 9 TMT experience | 15.79 | 3.595 | -0.25* | 0.13 | -0.13 | -0.10 | -0.05 | 0.56*** | -0.18 | -0.01 | 1 |
| 10 TMT tenure | 4.62 | 2.443 | 0.09 | 0.41*** | 0.21 | 0.05 | 0.24* | 0.29** | 0.07 | -0.15 | 0.35** |

N=77, significance levels: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ (two-tailed tests)

**Table 3: Descriptive statistics and Pearson correlation coefficients**

### *3.4.2 Results of the event study analysis*

To test my hypotheses I use hierarchical clustered moderated regression analyses controlling for within-firm error correlation. More specifically, I run a pooled OLS regression analysis and estimated standard errors that are robust to heteroskedasticity and intra-cluster correlation (Wooldridge, 2002). This method allows me to account for the hierarchical nature of my data since some firms in my sample experienced more than one NPD failure. In Table 4 I report results for five models. Model 1 represents the base models and covers control variables only, Model 2 includes main effect of my independent variables, and Model 3 includes all direct and interaction effects. My results for other event windows surrounding NPD failures are presented in Models 4 and 5 as robustness checks. While I report estimated coefficients and robust standard errors for the full model, I also include the increase in explained variance ($\Delta R^2$) for control variables, direct effects, and interaction effects estimated based on hierarchical regressions. The R-squared for the full models are statistically significant and significantly better at explaining variance of the cumulative abnormal returns associated with NPD failure as compared to reduced models. This indicates that the full model has significantly more explanatory power than the base line and main effect only models. On average, I observe over the three-day event window CAR (-1, +1) negative abnormal returns for firms experiencing late stage NPD failures. This finding is similar to prior work by De Carolis et al. (2009), Girotra et al. (2007), and Sharma and Lacey (2004).

| | Hierarchical regression analysis | | | | Alternative event windows | |
|---|---|---|---|---|---|---|
| Model | 1 | 2 | 3 | | 4 | 5 |
| Dependent Variable | CAR (-1,+1) | CAR (-1,+1) | CAR (-1,+1) | Eta² | CAR (-1,0) | CAR (-2,+2) |
| Constant | 0.31 (0.42) | 0.28 (0.44) | 0.65 (0.43) | | 0.69 (0.44) | 0.58 (0.46) |
| *Control variables* | | | | | | |
| Firm age | -0.00 (0.01) | -0.00 (0.01) | -0.01 (0.01) | .006 | -0.00 (0.01) | -0.01 (0.01) |
| Firm size (in 1,000 empl.) | 0.02 (0.01)* | 0.01 (0.01) | 0.00 (0.01) | .004 | 0.00 (0.01) | 0.01 (0.01) |
| Cash / Firm size | -0.31 (0.13)* | -0.31 (0.12)* | -0.21 (0.13) | .033 | -0.22 (0.14) | -0.24 (0.12) |
| TMT size | -0.00 (0.02) | -0.01 (0.02) | -0.01 (0.02) | .009 | -0.02 (0.02) | -0.01 (0.02) |
| TMT age | -0.01 (0.01) | -0.01 (0.01) | -0.01 (0.01) | .038 | -0.01 (0.01) | -0.01 (0.01) |
| *Main effects* | | | | | | |
| Revenue/ Firm size (R) | | 0.02 (0.03) | 0.08 (0.03)* | .073 | 0.08 (0.03)** | 0.07 (0.03)* |
| R&D intensity (RD) | | -0.08 (0.03)* | -0.10 (0.04)** | .102 | -0.08 (0.04)* | -0.10 (0.04)* |
| TMT experience (TE) | | -0.07 (0.04) | -0.05 (0.03) | .030 | -0.05 (0.04) | -0.06 (0.03) |
| TMT tenure (TT) | | -0.05 (0.04) | 0.05 (0.04) | .024 | 0.05 (0.04) | 0.06 (0.04) |
| *Cross-level Interactions* | | | | | | |
| TE x R | | | 0.06 (0.02)** | .131 | 0.07 (0.02)** | 0.06 (0.02)** |
| TE x RD | | | 0.07 (0.03)* | .075 | 0.07 (0.04) [1] | 0.07 (0.03)* |
| TT x R | | | 0.00 (0.05) | .000 | 0.02 (0.05) | 0.00 (0.05) |
| TT x RD | | | -0.08 (0.05) | .028 | -0.06 (0.06) | -0.07 (0.06) |
| Observations (clusters) | 77 (50) | 77 (50) | 77 (50) | | 77 (50) | 77 (50) |
| R-squared | 0.155 | 0.313 | 0.393 | | 0.376 | 0.413 |
| Delta R-squared | | .159 * | 0.080 * | | - | - |

**Note:** cluster-robust standard errors reported in parentheses. Eta² is reported as a measure of effect size.
Significance level: * p < 0.05, ** p <0.01, *** p <0.001 (two-tailed tests); [1]p = 0.07

**Table 4: Hierarchical Moderated Regression Analysis (OLS)**

Table 4 shows that, as hypothesized, more R&D intensive firms are on average associated with larger drops in market values after late stage NPD failure ($\beta_{RD}$ = -0.08 with $p<0.01$). The significant and negative coefficient provides support for Hypothesis 1. With respect to firm revenues, my results show support for Hypothesis 2, since on average more firm revenues have a significant positive effect ($\beta_R$ = 0.06 with $p<0.05$) on CAR. Regarding the moderation effect of TMT experience, I find statistically significant interactions between TMT industry experience and both (i) firm R&D intensity ($\beta_{TExR}$ = 0.06 with $p<0.01$); and (ii) firm revenues ($\beta_{TExRD}$ = 0.07 with $p<0.05$). However, my data do not support Hypotheses 4a and 4b; corresponding interaction terms are not significantly different from zero. I obtain similar results when regressing the variables on different lengths of event windows CAR (-1, 0) and CAR (-2, +2). Thus, my results are robust toward alternative measures of CAR.

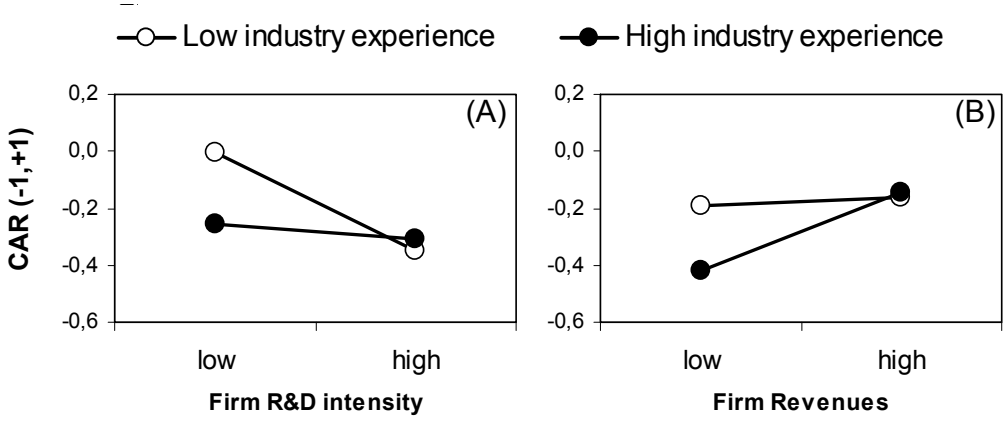


**Figure 6: Interaction effects between levels of TMT industry experience and (A) Firm R&D intensity, (B) Firm Revenues**

**Source: Own illustration**

In order to better understand the moderation effect of industry experience, in Figure 6A I plot R&D intensity on an x-axis and CAR (-1, +1) on a y-axis and separate plots for high and low industry experience. Figure 6A shows that the negative relationship between firm R&D intensity and CAR (-1, +1) is diminished when the firms' top managers have more industry experience. Moreover, in Figure 6B I plot firm revenues on an x-axis and CAR (-1, +1) on a y-axis and provide separate lines for TMTs with high and low industry experience. Figure 6B shows that the positive relationship between firm revenues and CAR (-1, +1) is strengthened when firms have TMTs with more industry experience. These findings support my Hypotheses 3a and 3b.

### 3.5 Discussion and conclusion

In this study, I examined how firm specific resources impact the market value of firms after new product development failures, acknowledging that this relationship may depend on the industry and firm specific experiences of the firm's top management team. My results shows that biotechnology firms experiencing late stage NPD failures lose, on average, 21.9% more market value relative to the NASDAQ Biotechnology Index. My results further demonstrate that high levels of firm R&D intensity enhance this negative effect while high firm revenues diminish it. Moreover, my data reveals that TMT industry experience moderates both effects, while TMT tenure has no significant influence.

### *3.5.1 Theoretical implications*

My findings are consistent with existing literature on new product development suggesting that firm specific resources can explain heterogeneity of event severity across firms. Much of the NPD literature has focused on the impact resource endowments have on firm market valuation during adverse events. De Carolis et al. (2009) investigate how firm characteristics can mitigate negative consequences after NPD failure announcements. Using data on 57 biotechnology firms experiencing 104 drug terminations they show that strategic alliances, product pipelines, technological competence, and high level of R&D intensity can buffer adverse events. Girotra et al. (2007) examine the valuation of NPD projects by conducting an event study on 169 failures of biotechnological firms. Focusing exclusively on clinical Phase III failures, they explain heterogeneity in NPD project valuation based on interactions with the development stage of the failed NPD project and other new product candidates suggesting that portfolio-level interactions should be taken into account when explaining investor reactions to failures. Moreover, Morrow et al. (2007) analyze data on 178 manufacturing firms that have failed to meet investors' expectations. Their results demonstrate that difficult-to-imitate strategies recombining firms' existing stock of resources are positively related to firm recovery. I extend these findings and add to the NPD literature by investigating how NPD failures can be mitigated by firm specific resources contingent on the top management team experience.

Much of the existing Upper Echelon literature focuses on how the composition of TMTs impacts organizational performance (Marcel, 2009; Cannella

et al., 2008; Kor, 2003; Hambrick and Mason, 1984) and firm market values (Zhang and Wiersema, 2009; Goll et al., 2008; Jensen and Zajac, 2004). However, this stream of literature is silent on the role of top management teams when firms experience adverse events such as NPD failures. This is surprising given that TMT demographics influence a firm's propensity toward strategic change such that this propensity is greater when TMT age is lower and TMT tenure is shorter (Wiersema and Bantel, 1992). Extending this literature, I find that TMT experience can buffer the decline in firm market value after NPD failure by (i) diminishing the negative effect of R&D intensity and (ii) enhancing the positive effect of firm revenues on post-failure valuation. These results provide insight into investors' view on the role managerial experiences needed to recover from adverse events, and when these experiences are more or less valuable contingent on the firm's R&D intensity and revenues.

Although I do not hypothesize main effects of managerial experience on firm market value after NPD failure, my data show that the main effect of TMT tenure is statistically insignificant, albeit the sign of the variable is positive, as expected. Surprisingly, regarding TMT industry experience I also find no significant main effect, but the sign of the coefficient is negative. One possible explanation of this unexpected finding is provided by Cohen and Dean (2005) who argue that top management teams with more industry experience raise investors' expectations of firm success. That is, industry experience among TMT members signals that TMTs are familiar with market conditions in a specific sector and may have the ability to lead the company through challenging situations (Kor and

Misangyi, 2008). In case of NPD failures, investors might be more disappointed when a firm operating with industry experienced managers fails in NPD and, consequently, may penalize the firm for more than just the lost new product compound (Girotra et al., 2007). While this is just an ex post interpretation, future research should test this explanation more thoroughly.

Some of my secondary findings prove my data being consistent with previous studies. In particular, the result that firm age had no significant mitigating effect in my study is consistent with recent observations by De Carolis et al. (2009) who show that in case of an adverse event neither liabilities of newness nor senescence impact a firm's ability to deal with a NPD failure. Moreover, with respect to TMT size and TMT age I observe no mitigating effect, which is in line with previous work by Boeker (1997) and Wiersema and Bantel (1992) who find that average TMT size and TMT age were negatively related to change in firm strategy. The consistency of my results with prior studies in this field makes me confident that my results can be replicated in other studies, as well.

### *3.5.2 Practical implications*

My findings have implications for practice, especially for managers of high technology firms since they allow them to better understand the financial consequences of potential NPD failures. Specifically, my results emphasize the strong influence that investors' perceptions of firm specific resources have on value destruction during NPD failures suggesting that the development of an appropriate resource base can, partly, buffer high technology firms against declines in firm market values. I demonstrate that firm revenues may actually reduce negative

consequences of NPD failure for the firm's market value while in contrast; R&D intensity enhances this negative effect. However, this study suggests that firm specific resources are not necessarily buffering or fostering *per se*, but need to be efficient put in use by managers with a high level of industry experience. Investors seem to consider firm specific resources in conjunction with the firms' managerial experience. My findings therefore suggest that it is not firm specific experience (firm tenure) that matters but industry specific experience. It appears that recruiting managers (or perhaps outside directors) with substantial industry experience can help to diminish the impact of failures on firm market valuation.

### *3.5.3 Limitations and future research*

As all studies, this one has limitations which in turn provide opportunities for future research. One issue concerns my focus on US biotechnology firms, and thus on a single high technology industry. While this sampling technique rules out methodological threats such as potential confounding events (Zheng et al., 2010), it raises the question of generalizability to a larger population. Caution must be exercised when transferring results from one single industry to others (Girotra et al., 2007). I hope that future research will verify my findings in settings other than the US biotechnology industry. Furthermore, I exclusively focus on publicly traded companies listed on the NASDAQ Biotechnology Index to better operationalize the relative difference between the benchmark index and the firm stock price after NPD failure to control for potential confounding events. However, my measure of CAR is incomplete to the extent that focal firms' losses in stock price marginally influence the performance of the benchmark index itself. Although my approach is

consistent with Michaely et al., (1995) arguing that measurement of the CAR by using a fitting index is beneficial to avoid overlapping events that are industry specific, more work is needed to examine alternative measures of the CAR.

### *3.5.4 Conclusion*

In conclusion, this study shows how R&D intensity and firm revenues affect firm market value after NPD failures, contingent on managerial experience. I find that top managers' industry experience, but not their firm-specific experience, can buffer the decline in firm market value by (i) diminishing the negative effect of R&D intensity and (ii) enhancing the positive effect of firm revenues on post-failure valuation. This suggests that in case of NPD failures investors view industry-specific experience as crucial for top managers to effectively and efficiently use the resources at hand for recovering from failure. My study advances our understanding of investor reactions to NPD failures and the complexity of these reactions.

# 4 Can good news blur bad news? Firm resources, and the simultaneous announcement of new product development failures and successes[4]

In this chapter, I propose a model addressing simultaneous announcements of good and bad news to cope with new product development failures. Drawing on resource-based theory in concert with literature on announcement effects, I postulate that the positive effect of good news regarding other NPD projects is contingent on the firm specific resource endowment. Using a unique dataset of NPD failures by US biotechnology firms I show that simultaneously announced good product news can counterbalance negative investor reactions to NPD failure. However, this effect significantly depends on a firm's R&D intensity, cash position and revenues. My data reveals that well-timed good product news can mitigate NPD failures and emphasize the role of firm resources in this process. In Section 4.1 I give an introduction to the topic. Then I derive my set of hypotheses by reviewing the literature on NPD failure and announcement effects in Section 4.2. I describe the research method used in Section 4.3 and present the results of the study in Section 4.4. In Section 4.5 I discuss the results and conclude by reviewing implications for practice as well as limitations of the study.

[4] This section is based on Buerger, Urbig and Patzelt (2010) and has been accepted for presentation in a Divisional Paper session at the 2010 Academy of Management Annual Meeting, August 6-10, 2010, in Montreal, Canada.

## 4.1 Introduction

In dynamic environments populated by high technology firms, new product development is a key determinant of firm success (Buganza et al., 2009; Montoya-Weiss and Calantone, 1994; Brown and Eisenhardt, 1995). Developing a portfolio of new products is essential for gaining early cash flow, market share, and external visibility, and increases the likelihood of firm survival (Robinson and Chiang, 2002; Bhattacharya et al., 1998; Schoonhoven et al., 1990). However, due to the technological uncertainties intrinsic to the NPD process, failure rates in innovation-driven industries are substantial (De Carolis et al., 2009; Buganza et al., 2009; Evans and Varaiya, 2003). NPD failures decrease the value creating capacity of a firm and, typically, result in substantial drops in firm market value (Sarkar and de Jong, 2006; Sharma and Lacey, 2004). Previous studies make important contributions by showing that negative valuation effects after NPD failure are significantly influenced by firms' idiosyncratic organizational characteristics (De Carolis et al., 2009; Girotra et al., 2007). However, these studies neglect the potential impact of simultaneously announced good news regarding other products even though a substantial body of literature shows that positive product news substantially enhances the market value of high technology firms (Sarkar and de Jong 2006; Sharma and Lacey 2004; Liu 2000; Yermack 1997).

In order to mitigate negative valuation effects from NPD failures, managers may systematically combine NPD failure announcements with announcements of NPD success. In this study, we refer to announcements of NPD failures as significant negative events (De Carolis et al., 2009; Girotra et al., 2007), whereas

announcements of NPD successes ("good news") denote substantial positive events (Himmelmann and Schiereck, 2009; Hall et al., 2005). For example, Gilead Sciences Inc. announced on February 8, 2007 positive product news regarding the drug NS4A, and simultaneously to stop the development of the drug GS 9132. Another biotechnology company, SuperGen Inc. announced on January 3, 2005 that it has withdrawn its New Drug Application for the drug Orathecin, and simultaneously that the new product candidate Dacogen was accepted for filing by the United States Food and Drug Administration.

These examples raise two questions: First, do positive product news combined with the NPD failure announcement have a significant effect on market valuation of high technology firms? Second, might the effect differ with respect to firm specific characteristics? It is surprising that the effect of good news in the context of failure announcements has not been investigated so far. This study seeks to close this gap and investigates how simultaneously announced good product news can mitigate the effect of NPD failure announcements on firm value, and how firm resources moderate the effect of good product news when failures are announced. We test our hypotheses in the context of the US biotechnology industry using event study methodology and data on 75 late stage NPD failures announced during the years 1994 to 2008. We extend existing literature in three ways.

First, while scholars show that investors do react to the announcements of NPD processes (Hendricks and Singhal, 2008; Alefantis et al., 2007), this study suggests that this reaction is more complex than previously assumed. Existing NPD failure studies usually propose a direct relationship between firm characteristics and

investors reaction to NPD failure (De Carolis et al., 2009; Sarkar and de Jong, 2006; Rzakhanov, 2004). Our findings challenge this simplified view by demonstrating that combining NPD failure news with good news regarding other products can substantially influence investors' reaction. Moreover, this effect is moderated by the resource pool of the high technology firm experiencing the failure.

Second, although parallel announcements of good product news and NPD failures are not rare events and might be used strategically by firms to mitigate the impact of failures on firm value, existing studies have not explicitly controlled for good news but eliminated events where both announcements occur in parallel. This might bias results related to understanding the effects of bad news. For instance, to account for overlapping events (which might include good news), previous studies explicitly focus on narrow event windows (Girotra et al., 2007; Nixon et al., 2004). However, since managers may tend to make good product news announcements in either the same press release or in a narrow window surrounding the NPD failure announcement, narrow event windows might never be narrow enough. Explicitly addressing the effect of good news in the context of announcements of failures improves our understanding of market reactions to NPD failures. It appears that parallel announced good product news significantly alter the impact that firm specific variables have on market valuation after NPD failure suggesting that these factors need to be considered *conjointly* to gain a more detailed understanding on the consequences of failed NPD projects.

Finally, this study has practical implications for managers of high technology firms since it allows them to better anticipate financial consequences of NPD failure. It appears that managers can systematically use the combination of announcement of good and bad new as a strategic tool to mitigate decreases in firm market values after NPD failure.

The paper proceeds as follows. In the second section the conceptual background for the model is presented and five hypotheses are derived. Next, we describe the research methodology and the empirical results of the event study. Finally, in the fourth and final section, we review the outcomes and the implications of the study, including limitations and the potential for future research.

### 4.2 Theory development

*NPD failure announcements, good news, and firms' market valuation.* The visibility of NPD outcomes significantly impacts investors' perceptions and market valuation of high technology firms (De Carolis et al., 2009; Sarkar and de Jong, 2006; Sharma and Lacey, 2004; Kelm et al., 1995). Announcements of negative events such as NPD failures can substantially damage companies since they deteriorate the perceived value-creating capacity of the firm (Sarkar and de Jong, 2006; Rzakhanov, 2004). Moreover, NPD failures provide negative signals to investors indicating decreased future cash flows and firm performance (Sharma and Lacey, 2004). Consequently, particularly for advanced NPD projects failure typically result in disappointed investor expectations leading to significant drops in firm market values (De Carolis et al., 2009; Rzakhanov, 2004).

Firm specific resource endowments can significantly enhance or mitigate negative valuation effects of NPD failures on market valuation of high technology firms. For example, using a dataset of 169 drug development failures in clinical phase III, Girotra et al. (2007) show that other NPD projects targeting the same market as the failed product, as well as a strong sales position of a firm, significantly buffer negative valuation consequences of NPD failures. Moreover, Guedj and Scharfstein (2004) use a dataset of 235 cancer drug candidates to show that single-product, early stage firms are more likely to fail in bringing NPD projects to market launch than older firms or firms with more products under development. Further, this effect is even stronger for firms with more cash at hand. Rzakhanov (2004) draws on a sample of 220 publicly traded companies of the US biotechnology industry and finds that investors recognize the importance of new product development for the future profitability of firms as they expect those assets to become marketable products in the future. Finally, in a recent study, De Carolis et al. (2009) investigate 57 publicly traded biotechnology firms experiencing 104 NPD failures during the period 1992 and 2003 and find that organizational slack, technological capabilities and strategic alliances prior to potential product setbacks buffer the impact of NPD failures on market valuation.

While these studies demonstrate the impact of firm specific resources and other variables on market valuation after NPD failure announcements, they neglect parallel announcements of good news. However, there is a substantial body of research on the effects of good news showing that announcements of firm good news can positively impact market value of high technology firms (Sharma and

Lacey 2004; Liu 2000; Yermack 1997). While this literature is inconclusive about a broad definition of firm good news, previous studies show that market values significantly increase in consequence of announcements of successful patent applications (Hall et al., 2005), increases of R&D expenses (Chan et al., 2001), and positive product news from the FDA (Sarkar and de Jong, 2006). Milgrom (1981) argues that the announcement of good news about a firm's prospect always raises its stock price. These arguments and findings suggest that in the context of NPD failure simultaneously announced good product news will act as positive signal towards investors regarding the firms' ability to recover from failure. Due to investors expectations regarding potential future profits this will, in turn, buffer the drop in market valuation after NPD failure announcements. Thus,

*H1: The decline in market value after NPD failure announcements is weaker when firms simultaneously announce good product news.*

**Heterogeneity of good product news**

Good news related to new product development progress are not homogeneous. Specifically, there is heterogeneity related to whether firms announce NPD progress in early or late stages of development. A growing body of literature shows that good news regarding late stages of NPD processes are accompanied by significant increases in firm market values due to decreasing uncertainty for investors (Himmelmann and Schiereck 2009; Sarkar and de Jong 2006; Kelm et al. 1995; Bosch and Lee 1994). These observations are consistent with previous findings by Ely et al., (2003), demonstrating that for newly

developed drugs clinical phase II appears to be the first point at which a potential new product candidate is given significant value-relevance by investors. Consistently, Dedman et al. (2008) point out a stage dependency of stock market reactions to positive NPD related announcements. Just recently, Himmelmann and Schiereck (2009) demonstrate that the valuation effect of good product news announcements is most significant at late stage cornerstones of the NPD process.

Furthermore, research on late stage NPD failures indirectly supports the hypothesis that the announcement of late stage NPD progress is more influential on firm value than announcement of early stage progress. Failures during late stages of development result in strongly disappointed expectations by the firms' investors (Girotra et al., 2007; Rzakhanov, 2004) because in late stages already huge resource investments have been made (Himmelmann and Schiereck, 2009). As one consequence late stage NPD failures typical lead to significant losses in firm market value (Girotra et al., 2007; Guedj and Scharfstein, 2004). These findings are consistent with observations by Rzakhanov (2004) showing that late stage failures of NPD projects are associated with sharper drops in firm market value than early stage failures. This suggests that late stage good product news will better buffer the announcement of NPD failures than good news related to early stage NPD processes. Thus,

*H2: The decline in market value after NPD failure announcements is weaker when firms simultaneously announce good product news, but more so if good product news refer to late stage projects than when they refer to early stage projects.*

**The moderating effect of firm specific characteristics**

Market valuation of firm announcements can be substantially influenced by firm specific characteristics. For example, the negative impact of NPD failure can be mitigated by a strong product pipeline since financial markets evaluate knowledge assets and product development activities with respect to future cash flows and profits (Rzakhanov, 2004). Moreover, Girotra et al. (2007) highlight the importance of firm sales in mitigating negative valuation effects after NPD failure. De Carolis et al. (2009) find that organizational slack, technological capabilities and strategic alliances provide a significant buffer to NPD failure.

Further work suggests that investors' expectations that are caused due to good news may also depend on firm specific characteristics. For example, while De Carolis et al. (2009), Liu (2000) and Chan et al. (2001) argue that higher R&D intensity indicates firms' capability to develop more innovative new products thus raising investor expectations, Rzakhanov (2004) and Guedj and Scharfstein (2004) suggest that a stronger cash position enables firms to draw on more strategic options such as mergers and acquisitions to advance their product portfolio. Moreover, high firm revenues signal to investors that the firm has successfully commercialized a promising NPD candidate, and that it is therefore able to transform basic research into marketable new products (Girotra et al., 2007). We now investigate how R&D intensity, firm cash, and firm revenues moderate the buffering effect of good product news in the context of NPD failure announcements.

*R&D intensity*. A firm's innovative effort, measured by its level of R&D intensity, denotes its potential to create and transform internal knowledge into marketable products (Cohen and Klepper, 1992). High levels of firm R&D intensity signal towards investors that a firm has invested comparatively more of its resources into R&D projects (De Carolis et al., 2009, Xu et al., 2007) and investors will build up expectations that the product candidates of R&D intensive firms will reach market launch and generate profits (Rzakhanov, 2004; Chan et al., 2001). This is particularly the case when NPD candidates have already reached later development stages (Rzakhanov, 2004). However, in case such NPD projects fail investors may interpret high levels of R&D intensity as inefficient allocation of firm resources and punish the firm due to their high a priori expectations regarding new product candidates entering the market.

In contrast, announcements of good product news of high R&D intensive firms are significantly better evaluated by investors compared to good product news of less R&D intensive firms due to investors' perception that more R&D intensive firms are better able to develop more innovative new products (Chan et al., 2001). In this context, Himmelmann and Schiereck (2009) argue that announcements of late stage good news regarding other promising NPD projects significantly reduce investors' uncertainty and lead to significant increases in market values of high technology firms. Therefore, it appears that high levels of R&D intensity will lead to less sharper drops in market valuation in case high technology firms announce late stage NPD failure news and late stage good product news simultaneously. Thus,

*H3: The decline in market value after NPD failure announcements is weaker when firms simultaneously announce good product news, but more so for firms with high R&D intensity than for firms with low R&D intensity.*

*Firm Cash.* Literature on financial slack of firms, measured by available cash and cash equivalents (Harford et al., 2008; Patzelt et al., 2008; Mishina et al., 2004), demonstrates that a strong cash position provides the firm with better options to acquire resources necessary for successful new product development. Moreover, a strong cash position offers the firm opportunities to maintain control over its new product candidates and to appropriate the full profits once these NPD candidates have entered the market (Rothaermel and Deeds, 2004; Lerner and Merges, 1998). These advantages suggest that investors will have higher expectations that new product candidates will succeed and generate high revenues for the firm when the firm is in a strong cash position than when it has little cash at hand. In case of NPD failures – when investors' expectations are not met – firms with a strong cash position will suffer more from NPD failure than those with a weak cash position.

When firms announce NPD failure news and good product news simultaneously, one might expect that a stronger cash position may foster the positive valuation effect of parallel announced good product news. Previous work (Zhang, 2006; Koku et al., 1997) shows that the positive valuation effect of announced good news is stronger in case a firm has more cash at hand because firms with more cash can reduce costs of raising external funds since they are able

to develop and finance promising NPD candidates without external partners (Levitas and McFadyen, 2009). Thus,

*H4: The decline in market value after NPD failure announcements is weaker when firms simultaneously announce good product news, but more so for firms in a strong cash position than for firms in a weak cash position.*

*Firm Revenues***.** Firm revenues are evaluated by investors as most relevant information for firm market valuation, even more market relevant than traditional earnings and operating cash flows (Xu and Cai, 2009). This signaling effect of firm revenues significantly differs depending upon the development stage of the NPD project (Guedj and Scharfstein, 2004). Firms currently generating high revenues indicate to investors that they will earn substantial money with their successfully completed NPD projects in the future because they have already shown to be able to transform basic research into marketable products (Chandra and Ro, 2008). In case of NPD failure, however, those firms generating high revenues will suffer more than firms earning fewer revenues due to increased investor expectations (Guedj and Scharfstein, 2004).

However, in case high technology firms announce NPD failure news and good product news simultaneously, investors will put more emphasis on the announcement of good product news when firms already generate high revenues because those firms are seen to be better able to successfully commercialize new product candidates and generate future profits to the firm and its investors. Therefore, high levels of firm revenues will lead to less sharper drops in firm

market valuation in case high technology firms announce late stage NPD failure news and late stage good product news simultaneously. Thus,

*H5: The decline in market value after NPD failure announcements is weaker when firms simultaneously announce good product news, but more so for firms with high revenues than for firms with low revenues.*

## 4.3 Methodology and data collection

### *4.3.1 Sample characteristics*

We chose the biotechnology industry in the United States to test our five hypotheses. This sector is well suited for our analysis since it is a relatively young and invention intensive sector where new product development is critical for firm success and performance (De Carolis et al., 2009; Girotra et al., 2007; Green et al., 2003). However, transforming research into marketable new drugs is a complex, capital-intensive and highly risky endeavor since new drug candidates have to enter a number of regulated stages till market approval (Himmelmann and Schiereck, 2009; Xu et al., 2007; Rothaermel and Deeds, 2006). It typically starts with basic research in the lab, followed by pre-clinical studies where the new drug candidate that emerges from the laboratory research is tested in animal studies. Subsequently, the potential new product must be tested in three clinical stages to ensure both the safety and effectiveness in human subjects. Succeeding this, each drug must complete the New Drug Application review process before the Food and Drug Administration may approve the drug for the US market (Sarkar and de Jong, 2006; Rzakhanov, 2004; Evans and Varaiya, 2003). Based on scientific and financial

information, firms must decide after each development stage whether to continue with the next even more expensive phase or to terminate development (Abrantes-Metz et al., 2005; Guedj and Scharfstein, 2004).

Our sample consists of publicly traded American biotechnology firms listed on the NASDAQ Biotechnology Index between 1994 and 2008. To ensure homogeneity of our sample with respect to technology and new product development activities, we only include firms commercializing drugs for the detection and treatment of diseases. Moreover, we exclusively focus on late stage NPD failures (Phase III clinical trial and NDA filing phase) as they are most value relevant for investor valuations of firms (Xu et al., 2007; Rzakhanov, 2004). NPD failures happening during later stages are significantly more harmful for firm market valuation due to high resource commitments made (Girotra et al., 2007). Consistent with previous studies in this field (e.g., De Carolis et al. 2009; Rzakhanov, 2004), clinical trial data was collected from ReCap database. Additional data was collected from The Wall Street Journal, MarketWatch, LexisNexis and company web pages.

Our initial sample of 92 US biotechnology firms experienced 593 failures at clinical trial stage during between 1994 and 2008. A total of 306 NPD failures were excluded from the dataset since information of the exact failure date or the failed product's stage was not available. Moreover, we had to drop 87 failures because firm financial data at the time of the NPD failure date were not available. Additionally, personal communication with ReCap employees yielded that failures which were listed in the database as having occurred on the first day of a month can

indicate NPD failures for which only the month, but not the accurate event day, could be correctly identified by ReCap. Therefore, we crosschecked all failure dates with the companies' press releases and SEC filings leading to an additional drop of 34 data points for which such cross-validation was not successful. After eliminating these cases we end up with 166 NPD failures, including 77 late stage failures by 50 biotechnology firms. Of these 77 late stage failures, 25 failure announcements were combined with at lest one good product news. At the time of failure, firms were, on average, 14 years old and had about 1,446 employees. Market values of firms drop, on average, by -21.6% for clinical phase III failures, and by -24.6% for failures during the NDA filing phase. We find no significant difference between the decline in firm market value of these two phases (t-value 0.37, df = 74 with p = 0.71) supporting our decision to jointly consider them as late stage failures.

### *4.3.2 Measures*

*Dependent variable.* The dependent variable in our study, Cumulative Abnormal Return, captures the impact NPD failures have on firm market valuation of biotechnology firms (De Carolis et al., 2009; Campart and Pfister, 2007; Girotra et al., 2007). We control for potentially confounding events by identifying the exact event date and the optimal length of the event window (Zhang and Wiersema, 2009; Nixon et al., 2004; Brown and Warner, 1985). In order to ensure that we captured the exact event date, all observations identified in the ReCap database were double-checked using the companies SEC fillings and news reports provided

by LexisNexis. By doing so, the date of the earliest news release for every observation was identified.

In order to control for confounding industry-wide events, we use the NASDAQ Biotechnology Index as a benchmark for our event study, following suggestions by Hendricks and Singhal (2008) and Campart and Pfister (2007). We measure CARs based on market adjusted returns (Henderson, 1990) as the relative difference between the price of the benchmark index and company stock price during a three-day event window (Girotra et al., 2007; Nixon et al., 2004; Mc Williams and Siegel, 1997). While focusing on a narrow three-day event window, (-1, +1), we included the day prior to, the day of, and the day following the NPD failure announcement in our analysis. We also report results CAR (-2, +2) as a robustness checks, showing that our results are robust for different event windows. Whereas the mean CAR (-1, +1) in our event study is -21.9%, indicating that during this period the average firm market value decreased by 21.9% relative to the NASDAQ Biotechnology Index, we find similar results for CAR (-2, +2) (-22.5%). This demonstrates that the market reaction to NPD failure is strongly negative and is consistent with previous studies (De Carolis et al., 2009; Girotra et al., 2007; Sarkar and de Jong, 2006; Rzakhanov, 2004). Note that event windows are defined with respect to trading days in the United States.

*Independent variables.* We use four independent variables, three of them representing firm specific characteristics and one good product news. First, with respect to the firms' innovative effort, we include *firm R&D intensity*. Due to strong correlation between R&D expenditures and firm revenues, we cannot

include the absolute level of R&D expenses and operationalize R&D intensity as R&D expenses divided by the number of employees (Graves, 1998; Baysinger et al., 1991; Hill and Snell, 1988). This is consistent with Scherer (1984) who argues that this measurement is generally regarded as the best proxy for innovation. Second, *firm cash* was taken from the 10-K SEC proxy fillings and the firms' annual reports in the period from before the NPD failure. Due to the skewness of the variable we use the natural logarithm of the firms' cash holdings as recommended by Harford et al. (2008). Third, *firm revenues* were also taken from the company's 10-K SEC proxy fillings and the firms' annual reports in the period from before the NPD failure. Since firm revenues are strongly correlated with firm size, we include the size corrected ratio of revenues over firm size by dividing revenues by the number of employees (Datta et al., 2005; Arora et al., 2001). Fourth, we operationalize good product news as announced positive product related news in context of NPD failure. Specifically, we include good product news of successfully completed steps in clinical development. We calculate this variable by collecting all good product news announcements from the day before till the day after NPD failure. In order to be able to distinguish good product news regarding different stages, all good product news were labeled regarding the clinical trial they belong to.

*Control variables.* We include three control variables in our analysis which potentially influence firm CAR in the case of NPD failures. First, we control for firm age since younger companies often face substantial resource constraints (Zheng et al., 2010; Shepherd et al., 2000; Deeds and Hill, 1996) suggesting that

investors will have lower expectations that they will recover from failure than older firms. We operationalize firm age as the number of days from firm inception to the NPD failure (De Carolis et al., 2009). Second, with respect to firm size, we use the firms' number of employees. Guedj and Scharfstein (2004) suggest that large firm size may signal better opportunities to access and control resources towards investors. Thus, the increase in available resources can buffer the impact of NPD failure and allows firms to recover more quickly. Third, as suggested by De Carolis et al (2009), we control for prior firm performance operationalized as return on assets. By doing so we are able to eliminate unobserved resources that may influence the investors' confidence in the firms' ability to survive the NPD failure. We validated all performance data by crosschecking with the companies' 10-K SEC proxy fillings and the firms' balance sheets for the fiscal year prior to the NPD failure announcement.

## 4.4 Results

### *4.4.1 Descriptive statistics and correlations*

Table 5 presents descriptive statistics and correlations for the variables in our sample. The correlation table shows a moderate correlation between firm size and three variables ($r>0.30$): firm performance, R&D intensity, and firm revenues. These relationships are not surprising; given that larger firms tend to show higher performance (De Carolis et al., 2009), and typically invest relatively less in R&D as compared to small firms (Rzakhanov, 2004; Chan et al., 2001). Moreover, larger firms typically have more revenues than small firms since they are more likely to have successfully developed and marketed a new drug (Guedj and Scharfstein,

2004). Consistent with prior work (Chandra and Ro, 2008; Jegadeesh and Livnat, 2006) we also find a moderate correlation between firm performance and revenues. However, none of the correlations are high enough to justify concerns about multicollinearity, which we tested calculating Variance Inflation Factors. We standardized all continuous variables that are part of an interaction term. All VIFs are below 3.5, which is an accepted level indicate that there are no problems due to multicollinearity in our data set (Rothaermel and Hess, 2007; Hair et al., 2005). Standardizing the variables, which includes mean-centering, allows interpreting the direct effects as average effect of variables, averaged over all values of the moderating variable (Cohen et al., 2003). The normality of the residuals is examined statistically for the final model using three normality tests: Neither the Shapiro-Wilk, Shapiro-Francia, nor the Skewness Kurtosis could not reject the null hypothesis of normality of the residuals.

| | Mean | S.D. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 CAR (-1,+1) | -0.22 | 0.28 | 1 | | | | | | | | | |
| 2 Firm age | 14.22 | 5.41 | 0.03 | 1 | | | | | | | | |
| 3 Employees (log) | 5.83 | 1.56 | 0.45*** | 0.40*** | 1 | | | | | | | |
| 4 ROA | -0.33 | 0.38 | 0.28* | 0.14 | 0.61*** | 1 | | | | | | |
| 5 R&D intensity | 0.27 | 0.23 | -0.39*** | -0.15 | -0.48*** | -0.39*** | 1 | | | | | |
| 6 Cash per employee | 0.23 | 0.22 | -0.29* | 0.02 | -0.35** | -0.04 | 0.26* | 1 | | | | |
| 7 Revenue per employee | 0.23 | 0.28 | 0.23* | 0.07 | 0.59*** | 0.57*** | -0.29* | -0.03 | 1 | | | |
| 8 Good product news | 0.57 | 0.82 | 0.38*** | -0.15 | 0.04 | 0.13 | -0.14 | -0.16 | 0.06 | 1 | | |
| 9 Good product news (early) | 0.25 | 0.61 | 0.13 | -0.11 | -0.03 | 0.04 | -0.10 | -0.11 | 0.01 | 0.75*** | 1 | |
| 10 Good product news (late) | 0.32 | 0.55 | 0.42 | -0.11 | 0.10 | 0.15 | -0.10 | -0.12 | 0.08 | 0.67*** | 0.04 | 1 |

N = 77, + p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001

**Table 5: Descriptive statistics and Pearson correlation coefficients**

*4.4.2 Results of the event study analysis*

| | Hierarchical Moderated Regression Analysis (OLS) | | | | | | | | | | Altern. ev. win. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Model | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | |
| Dependent Variable | CAR | (-1,+1) | CAR | (-1,+1) | CAR | (-1,+1) | CAR | (-1,+1) | CAR | (-1,+1) | CAR | (-2,+2) |
| Constant | -0.54 | (0.22)* | -0.69 | (0.23)** | -0.68 | (0.21)** | -0.63 | (0.20)** | -0.79 | (0.18)*** | -0.83 | (0.18)*** |
| *Control variables* | | | | | | | | | | | | |
| Age | -0.01 | (0.01) | -0.01 | (0.01) | -0.01 | (0.01) | -0.01 | (0.01) | -0.01 | (0.00) | -0.01 | (0.00) |
| Employees (log) | 0.07 | (0.04)+ | 0.08 | (0.04)* | 0.08 | (0.04)* | 0.07 | (0.03)* | 0.10 | (0.03)** | 0.10 | (0.03)** |
| ROA | -0.00 | (0.12) | -0.04 | (0.12) | -0.05 | (0.11) | -0.04 | (0.11) | -0.11 | (0.12) | -0.14 | (0.11) |
| R&D intensity | -0.05 | (0.03) | -0.04 | (0.03) | -0.04 | (0.03) | -0.04 | (0.02)+ | -0.07 | (0.02)*** | -0.08 | (0.02)*** |
| RD | | | | | | | | | | | | |
| Cash per employee | -0.03 | (0.04) | -0.01 | (0.04) | -0.01 | (0.04) | -0.02 | (0.04) | -0.01 | (0.04) | -0.01 | (0.04) |
| CA | | | | | | | | | | | | |
| Revenues per employee RV | -0.01 | (0.03) | -0.02 | (0.03) | -0.01 | (0.03) | -0.01 | (0.03) | 0.02 | (0.02) | 0.01 | (0.03) |
| *Good news* | | | | | | | | | | | | |
| Good product news | | | 0.11 | (0.03)*** | | | | | | | | |
| Good product news (early) | | | | | 0.05 | (0.04) | | | | | | |
| Good product news (late) | | | | | 0.18 | (0.05)*** | 0.18 | (0.05)*** | 0.28 | (0.04)*** | 0.25 | (0.03)*** |
| *Moderation effects* | | | | | | | | | | | | |
| GL x RD | | | | | | | | | 0.12 | (0.03)*** | 0.11 | (0.03)*** |
| GL x CA | | | | | | | | | 0.16 | (0.06)** | 0.10 | (0.05)+ |
| GL x RV | | | | | | | | | -0.09 | (0.03)** | -0.10 | (0.03)** |
| Observations (clusters) | 77 | (50) | 77 | (50) | 77 | (50) | 77 | (50) | 77 | (50) | 77 | (50) |
| Max VIF | 3.18 | | 3.20 | | 3.23 | | 3.18 | | 3.36 | | 3.36 | |
| $R^2$ (F value) | 0.271 | (5.24)*** | 0.368 | (5.71)*** | 0.404 | (5.19)*** | 0.391 | (6.39)*** | 0.527 | (10.91)*** | 0.507 | (9.55)*** |
| Model comparison | | | 1 | | 1 | | 3 | | 4 | | - | |
| $\Delta R^2$ (F value) | | | 0.097 | (14.51)*** | 0.133 | (6.51)** | -0.013 | (1.44) | 0.136 | (18.55)*** | - | |

**Note:** Heteroskedasticity- and cluster-robust standard errors reported in parentheses
+ p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001

**Table 6: Hierarchical Moderated Regression Analysis (OLS)**

Over the three-day event window we observe negative abnormal returns CAR (-1, +1) for firms experiencing late stage NPD failures, consistent with prior work (Buerger et al., 2010; De Carolis et al., 2009; Girotra et al., 2007; Sharma and Lacey, 2004; Rzakhanov, 2004). To test our five hypotheses we use hierarchical clustered moderated regression analyses controlling for within-firm error correlation. More specifically, we run a pooled OLS regression analysis and estimate standard errors that are robust with respect to heteroskedasticity and intra-cluster correlation (Wooldridge, 2002). This method allows us to account for the hierarchical nature of the data set since some firms in our sample experienced more than one failure.

Our results are presented in Table 6. While we report estimated coefficients and robust standard errors for the full model, we also include the increase in explained variance ($\Delta R^2$) for control variables, direct effects, and moderation effects estimated based on hierarchical regressions. We calculate five models. Model 1 is the base model and includes control variables only. This model is significant ($p < .001$) and explains 27.1 % of the variance in CAR (-1,+1). In Model 2, which is also significant ($p < .001$), we added the announcement of good product news (both early and late stage). This model explains 36.8 % of the variance, a significant increase ($p < .001$) as compared to the base model. In Model 3, we split good product news into early and late stage announcements. This significant ($p < .001$) model explains 40.4 % of the variance in CAR (-1,+1), significantly more than the base model ($p < .001$). Model 4 includes late stage announcements only, is significant ($p < .001$) and explains 39.1 % of the variance. Again, this increase is

significant as compared to the base model ($p < .001$). In Model 5 we add the interaction terms between good late stage product news and R&D intensity, cash, and revenues, respectively. This model is statistically significant. Importantly, the variance explained is 52.7%, a significant increase as compared to the base model ($p < .001$) and the main effect model (Model 4, $p < .001$). This indicates that the full model has significantly more explanatory power than the base line and main effect only model. Finally, Model 6 is a robustness check and corresponds to the full model but with CAR (-2,+2) as the dependent variable. This model is significant ($p < .001$) and explains 50.7% of the variance.

Model 2 in Table 6 shows that announcing good product news (early or late stage) is positively related to CAR (-1,+1) ($\beta_{GN} = 0.11$ with $p < 0.001$). This suggests that, on average, firms experience a smaller drop in market values when announcing NPD failures and good news simultaneously than when they announce NPD failures only. This provides support for our Hypothesis 1. Model 3 separately estimates the effects for good news about early and late stages of NPDs. A test for the difference of early and late good product news in Model 3 shows that the effect of late good product news is significantly more positive than for early good product news ($\beta_{GE} - \beta_{GL} = -0.13$, rob. S.E. = 0.06, $t = -2.13$, $p = 0.038$). This result suggests that late stage good news are more effective in buffering negative effects of NPD failure announcement on firm market value than early stage good news. This provides full for Hypothesis 2. Note that excluding announcements of good news related to early NPD stages in Model 4 does not significantly change the explanatory power of the model, and that the coefficient for late stage good product

news in Model 3 and 4 is basically identical. We therefore continue our analysis based on a reduced model that only includes announcements of good product news related to late stages of NPD.

To test Hypotheses 3-5 suggesting how firm specific characteristics can moderate the effect of good product news in context of NPD failure, we explore the interaction effects reported in Model 5. Model 5 reports a significant, positive interaction effect for good product news with firm R&D intensity ($\beta_{GLxRD}$ = 0.12, rob. S.E. = 0.03, t = 4.21, p < 0.001), a significant, positive interaction effect for good product news with cash ($\beta_{GLxCA}$ = 0.16, rob. S.E. = 0.06, t = 2.83, p= 0.007), and a significant, negative interaction effect for good product news with firm revenues ($\beta_{GLxRV}$ = -0.09, rob. S.E. = 0.03, t = -3.21, p = 0.002). In order to better understand these interaction effects we plot them in Figure 7. Figure 7 distinguishes between announcements of bad product news (NPD failures) only and simultaneous announcements of bad and good product news. The predicted CAR is plotted for high and low levels of the moderating variable, i.e. one standard deviation below and above its mean.

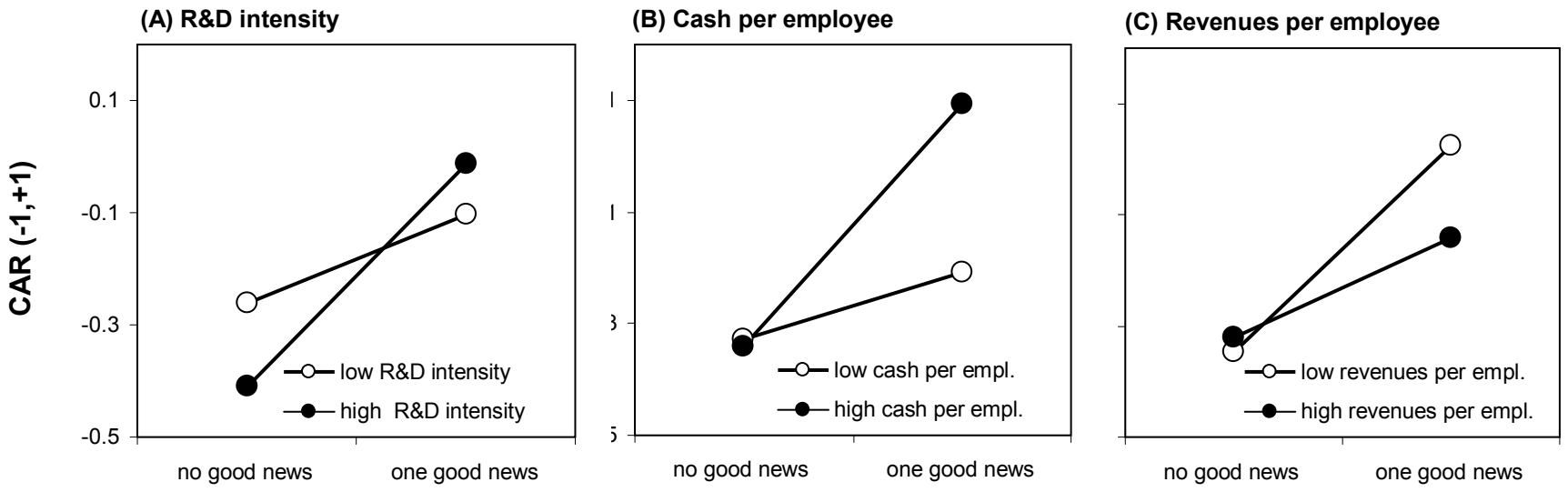


**Figure 7: Interaction between announcements of good product news and (A) R&D intensity, (B) Cash per employee and (C) Revenues per employee**

**Source: Own illustration**

Figure 7A illustrates that the effect of announcing good product news at the time of the NPD failure announcement is positively related to CAR (-1,+1), and the strength of this relationship increases with higher levels of R&D intensity, supporting Hypothesis 3. Interestingly, the plot demonstrates a cross between lines representing high and low levels of R&D. This indicates that the difference between firms with low levels of R&D intensity and those with high levels of R&D intensity is positive for firms with good product news announced together with the NPD failure message while it is negative for companies not simultaneously announcing good product news. While the coefficient $\beta_{RD}$ in Model 5 reflects the effect of firm R&D intensity if only bad news is announced and is significantly negative ($\beta_{RD}$ = -0.07, rob. S.E. = 0.02, t = -4.06, $p < 0.001$), the coefficient $\beta_{RD} + \beta_{GLxRD}$ in Model 5 reflects the same effect if good product news are announced and is significantly positive ($\beta_{RD} + \beta_{GLxRD}$ = 0.04, rob. S.E. = 0.02, t = 2.19, $p < 0.033$). That is, high R&D intensity is detrimental to firm valuation in case of NPD failure announcements, but it is beneficial to firm valuation if together with the failure announcement good product news is announced. This finding has interesting implications which we will discuss below.

Figure 7B demonstrates that the positive relationship between good product news and CAR (-1, +1) is stronger when the firm is in a strong cash position than when it is in a weak cash position. This finding provides full support for our Hypothesis 4.

Interestingly, Figure 7C shows that, in contrast to our Hypothesis 5, the positive relationship between good product news and CAR (-1,+1) is less positive

for firms with high revenues than for firms with low revenues. This is also reflected in the coefficient of the respective interaction term in Model 5, which is significant and negative ($\beta_{GLxRV}$ = -0.09, rob. S.E. = 0.03, t = -3.21, p = 0.002). Figure 7C further shows that the level of firm revenues has little impact in case the firm announces NPD failure only. However, in case of simultaneously announced good product news firms with low revenues benefit significantly more than firms with high revenues. We will discuss this interesting finding below.

Finally, as previous studies have done (e.g., De Carolis et al., 2009; Girotra et al., 2007) we checked our results for robustness and tested Model 5 for a different event window of five days (Table 6, Model 6). We find robust results; however, the significance of the interaction effect between firm cash and good news announcements becomes weaker ($p < 0.1$). This may be due to other overlapping events within the remaining two days added to the event windows which are not controlled for. All other results are robust in term of the size of the relevant coefficients and their significance, respectively.

### 4.5 Discussion and conclusion

This study aimed to shed new light on the role of good product news in the context of NPD failure announcements to explain heterogeneity of event severity across firms. We show that firm specific characteristics – R&D intensity, cash position, and firm revenues – can enhance or diminish the positive effect good product news have on market valuation in context of NPD failures and explain a significant share of variance in investors reaction to new product failures.

### *4.5.1 Theoretical implications for NPD literature*

Much of the existing literature on new product development has focused on firm specific factors that can foster or mitigate the negative valuation effect of a NPD failure (De Carolis et al., 2009; Xu et al., 2007; Sharma and Lacey, 2004), but these studies have widely neglected the valuation effect of simultaneously announced good product news. Indeed, to the best of our knowledge previous studies have only investigated the positive impact of good product news on market values of high technology firms, but have not acknowledged that these announcements can be used by firms to systematically counteract market reactions to NPD failures. For example, Sarkar and de Jong (2006), Bosch and Lee (1994), and Chaney et al. (1991) show that firm market values significantly increase in consequence of announcements of positive news from the FDA. Hall et al. (2005) find that market values significantly increase after announcement of successful patent applications. More recently, Himmelmann and Schiereck (2009) investigate stock market reaction to positive non-financial disclosures and finds that good product news provides important signals for investors in case the announcements have not been disseminated previously or anticipated by the market. We add to this literature by investigating the valuation effect of good product news in the context of late stage NPD failures and how this effect can be fostered or mitigated by firm specific characteristics. Furthermore, we acknowledge that there is variance in the type of good product new announced and their impact on NPD failures. Our data show that while the announcement of early stage news has little effect on firms' market value, late stage product news are more effective in buffering failure events.

The perhaps most important contribution of our study is that we show that the positive direct effect of good product news is not equal for all firms but significantly depends on their specific resource endowments. While our data reveals that firms with high R&D intensity can compensate for late stage NPD failures by simultaneously announcing good product news, this appears a less effective strategy for firms with low R&D intensity. Investors seem to interpret the role of R&D intensity differently in case the firm simultaneously announces bad news and good news or bad news only. This result is consistent with Chan et al. (2001) who find that good news of high R&D intensive firms lead to significantly larger increases in market value than good news announced by less R&D intensive firms. This suggests that a firm's R&D intensity should be considered by firm managers in order to effectively communicate NPD outcomes to investors.

As expected, our data show that the positive effect of simultaneously announced good product news in context of NPD failures is significantly enhanced when the firm has more cash at hand. This result complements previous findings by Koku et al. (1997) who demonstrate that the positive valuation effect of good news is even stronger in case a firm has a strong cash position. This finding also supports a recent study by Zhang (2006) who shows that favorable product news are significantly better evaluated by investors when the firm is in a stronger cash position since cash allows the firm to use more strategic options and to commercialize new product candidates independently from external partners.

Interestingly, investors appear to interpret positive good product news in the context of NPD failure announcements less favorable for firms with high revenues

than for firms with low revenues. These latter firms depend significantly more on simultaneously announced good product news. One explanation might be that investors will pay particular attention to the revenue generating potential (NPD success) when the firm is not yet profitable (has no or only minor revenues) because profitability is a prerequisite for long-term survival. This interpretation is consistent with Chaney et al. (1991) who argue that innovation should be more highly valued for smaller than for large firms, which need innovation more to stay on top of the market rather than to survive. Drawing on these arguments, we suggest that good product news announcement may signal towards investors that the company is on the right track and soon be able to generate profits for the firm and its shareholders. Future research can test these explanations.

Consistent with the resource-based view of the firm (Barney et al., 2001; Wernerfelt, 1984) our results highlight the complex interaction between organizational resources and investors' valuation of these interactions. Late stage new product candidates represent more valuable resources for a firm than early stage new product candidates since more investments has been made in late stage candidates. Consequently, the positive impact of good product news is significantly larger for later stages of the NPD process. Importantly, our findings demonstrate that other firm specific resources can significantly impact this positive valuation effect. In case of NPD failures investors appear to evaluate a firm not only based on the resources destroyed but also based on how existing resources could have contributed to the use of these destroyed resources. It appears that the composition of a firm specific resource pool, including interactions between resources, can

explain the impact of NPD failures on firm market valuation (De Carolis et al., 2009; Girotra et al., 2007; Rzakhanov, 2004).

### *4.5.2 Methodological implications*

From a methodological perspective, our study emphasizes that the investigation of overlapping events, rather than eliminating them from the sample, can yield interesting results because managers can use these simultaneous announcements as an effective communication strategy toward investors. Eliminating overlapping events and explicitly focusing on narrow event windows (Girotra et al., 2007; Nixon et al., 2004) does not acknowledge the fact that managers can use good product news in either the same press release or in a narrow window surrounding the NPD failure announcement to rescue market value in case of NPD failures. Simultaneously announced good product news significantly alters the impact that firm specific variables have on market valuation after NPD failure. Future studies might consider these factors *conjointly* to gain a more detailed understanding on the consequences of failed NPD projects.

### *4.5.3 Practical implications*

Our findings have implications for practice, especially for mangers of high technology firms since they allow them to better understand the consequences of potential NPD failures and their announcements. Specifically, our results highlight the influence that investors' perceptions of simultaneously announced good product news have on market valuation after late stage NPD failures, and that this impact is dependent on the specific characteristics of the firm. Managers who aim to combine

NPD failure announcements with good product news to effectively mitigate decreases in firm value should consider their resource endowments, specifically, the R&D intensity, cash position, and revenues of their firm.

### *4.5.4 Limitations and conclusion*

Of course, as all studies, this one has limitations which in turn provide opportunities for futures research. The first limitation is that we focus only on biotechnology companies, and thus on a single high technology industry. While this sampling technique rules out methodological threats (Zheng et al., 2010), it raises the question of generalizability to a larger population. We hope that future research will verify our results in settings other than the US biotechnology industry. Further, our event study is limited to the fact that other organizational characteristics and resources may influence the NPD failure announcement itself and, consequently, investor's valuation of the firm. Future research can shed more light on the potential impact of simultaneously announced financial statements as well as the role of simultaneously announced changes in the firm's other resources, for example its top management team or its strategic alliance partners.

In conclusion, our study shows that simultaneously announced good product news regarding other NPD projects explain a significant share of variance in the impact of NPD failures on market valuation of firms. Our findings highlight that this kind of announcement is a frequent phenomenon in practice and that the impact of good product news is contingent on firms' R&D intensity, firm cash and firm revenues. These findings advance our understanding of investors' perspective

of NPD failures and emphasize that event announcements and firms' resource endowments should be considered conjointly by future research.

# 5 The role of patent stocks in the context of new product development failures[5]

Existing literature suggests a positive influence of a firm's patent stock on financial performance (Hall, 2009; Morrow et al., 2007). Market expectations concerning future returns of NPD processes are included in the market valuation of innovative firms (De Carolis et al., 2009; Girotra et al., 2007). When NPD projects fail, due to disappointed market expectations one might expect that patent stocks will negatively impact investor reactions to failures. However, a buffering effect could also occur because large patent stocks may signal to investors that the firm has the potential to recover from failures. In this section, I integrate these two contrasting theoretical arguments to develop a model of the impact of patent stocks on investor reactions to NPD failures. Section 6.1 provides an introduction to this research topic. In Section 6.2 I review literature on the relationship between patent stocks and firm market values. Section 6.3 deals with the event study methodology I used to test my hypotheses. In Section 6.4 the results of the study are presented. Section 6.4 discusses these results and points out theoretical implications for the new product development and patent literatures.

[5] This section is based on Buerger, Urbig, Patzelt and Sandner (2010).

## 5.1 Introduction

A substantial body of literature investigating knowledge-based economies demonstrates that the competitive advantages of companies are based less on the allocation of physical resources than on intangible assets such as a company's patent stock (Levitas and McFadyen, 2009; Hsu and Ziedonis, 2008; Deng et al., 1999). Existing studies linking patents as important indicator of innovative activity and NPD outcomes to firms' market values show that patent data can provide substantially more market relevant information than traditional financial data (Chen and Chang, 2009; Bloom and van Reenen, 2002; Griliches, 1990). As patents represent a fundament for future returns, this is an important element of a firm's market value reflecting the sum of discounted future cash flows (Irvine and Pontiff, 2009; Hirshleifer, 2001; Sloan, 1996). With respect to patent data, previous research has distinguished between patent counts and patent quality. Empirical studies show that patent counts are positively associated with firm market values (Hall, 2009; Deng et al., 1999; Griliches, 1981). Extending this view, scholars argue that information on patent quality provides investors with a useful basis to judge the economic value of a firm's R&D effort (Hirschey et al., 2001; Hall, 2000). Hereby, a broad strand of literature shows that the two variables can be considered as credible indicators of patent quality are, thus, positively related to market values of innovative firms: forward citations (Hall et al., 2005; Harhoff et al. 2003) and backward citations (Lanjouw and Schankerman, 2004; Deng et al., 1999).

In a parallel research stream, strategy scholars find that in innovative-driven industries, new product development is a key determinant of firm performance (Buganza et al., 2009; Montoya-Weiss and Calantone, 1994). Developing a portfolio of potential new products is essential for gaining early cash flows, external visibility, and increasing the likelihood of firm survival (Robinson and Chiang, 2002; Bhattacharya et al., 1998). However, due to substantial market risks and technological uncertainties intrinsic to the NPD process, failure rates in innovation-intensive sectors are significant (De Carolis et al., 2009; Evans and Varaiya, 2003). NPD failures substantially hurt the value creating capacity of firms and, usually, result in sharp drops in market valuation (Sarkar and de Jong, 2006; Sharma and Lacey, 2004). Studies show that negative evaluations of NPD failures are substantially influenced by firm characteristics (De Carolis et al. 2009; Girotra et al., 2007; Rzakhanov, 2004). In order to mitigate the negative evaluation resulting from NPD failures, managers of innovative firms may systematically develop firms' resources to signal to investors that such an adverse event will not hurt the companies' economic future and chances for survival seriously. However, existing studies neglect strategies affecting indicators of a firm's intangible assets, which can influence (i.e., recover) market values after NPD failures. Managers of innovative firms may, for instance, systematically diversify a firms' patent stock to signal research quality to investors (Morrow et al., 2007; Hsu and Ziedonis, 2008).

In this study, we refer to patent stocks as a key resource on which investors build up their expectations regarding future cash flows and returns. While previous research indicates that the overall size of a patent stock affects firm market values

(Levitas and McFadyen, 2009; Himmelmann and Schiereck, 2009; Deng et al., 1999), we scrutinize whether patent stocks significantly affect firm market values after NPD failures. These effects might be caused by investors expectations raised by the presence of large patent stocks, but also by a patent stocks' role as a resource that may offer multiple opportunities for future NPD projects and thus to act as a buffer to NPD failures addressing only one or a few of such opportunities. It is surprising that the effect of patent stocks within the context of NPD failures has not been previously investigated. This study seeks to close this gap by examining how patent stocks influence the effect of NPD failure on firm market value, and how a firm's R&D strategy roughly mirrored by its R&D intensity may moderate this effect. We test our hypotheses using event study methodology concerning 154 NPD failures in the US biotechnology industry announced between 1994 and 2008.

With this work, we seek to extend existing NPD and patent literature. Although studies show that investors react to NPD outcomes (De Carolis et al., 2009; Hendricks and Singhal, 2008; Alefantis et al., 2004) and also highlight the beneficial role of patent stocks on firm market values (Chen and Chang, 2009; Harhoff et al., 2003; Hall, 2000), the role of patent stocks during NPD failure is still unexplored. By explicitly addressing how firm patent stocks affect firm market valuation after NPD failure, our understanding of investor reactions to failure is improved. Specifically, we are able to show that the higher expectations rose by larger patent stocks lead to larger disappointments in case of failures. However, this effect can be balanced by the fact that larger patent stocks may also offer potential

for firm recovery. This potential again depends on the firm's R&D strategy affecting the quality and structure of its patent stock.

Finally, this study has practical implications for managers of innovative firms since it allows them to anticipate market valuation consequences of potential NPD failures. Managers should be aware of existing knowledge asymmetries between them and investors. They should in particular be aware about how financial firm characteristics such as the level of R&D intensity and non-financial firm characteristics such as patent counts shape the way investors evaluate firm market values. While previous research has emphasized the positive role of patent stocks with respect to building higher market expectations, our study emphasizes that this comes at the cost of larger disappointments in case of NPD failures. It is up to the strategy employed by managers whether these costs balance the benefits of having higher expectations and market values before. It thereby also refers to whether managers prefer a stable or a more volatile firm valuation.

The present paper proceeds as follows. In the second section, the conceptual background for our model is presented and three hypotheses are derived. Next, we describe the research methodology and the empirical results of this study. Finally, in the fourth and final section, we review the outcomes and implications of the study, including limitations and potential avenues for future research.

### 5.2 Theory development

For knowledge- and research-driven companies, patent stocks are of great importance during both NPD processes and marketing activities since they confer a

time-limited exclusive right for manufacturing, using, distributing, and selling a protected invention in the territory where the patent has been granted (Hall, 2009; Levitas and McFadyen, 2009). Moreover, patents reflect a firm's innovative activity (Connolly and Hirschey, 1988; Pakes and Griliches, 1980) and secure potential cash flows and profits for a given period (Besen and Raskind, 1991). As Bloom and van Reenen (2002) put it, patents generate valuable real options because they exclusively allow its owner to develop and market new innovations. The innovation-driven biotechnology industry (as opposed to generic drug companies), in particular, relies on adequate patent protection, since only with the time-limited monopoly on new inventions firms can recover their large and risky R&D investments (Chen and Chang, 2009). Companies in this particular industry have a high propensity to patent new inventions and, therefore, patents are valid measures of a firms' inventive effort (Levitas and McFadyen, 2009). In this context, Mann and Sager (2007) highlight that biotechnological firms substantially rely on patents to protect their inventions and potential new products, and with it, their investment strategies.

Since patent stocks reflect the inventive output of a company (Pakes and Griliches, 1980; Scherer, 1983), and, thus, impact the ability of companies to capture sufficient revenues to recover their R&D efforts (Besen and Raskind, 1991), they have been found to contribute to the value of firms in financial markets (Bloom and van Reenen, 2002; Chen and Chang, 2009; Deng et al. 1999; Hall, 1993). In his seminal work, Griliches (1981) argues that the value of a company is the sum of its physical and intangible assets. Hereby, intangible assets comprise

knowledge assets such as R&D capabilities and patent stocks as well as market-based assets such as brands and reputation (Hall et al., 2007). Griliches (1981) finds that both R&D investments as well as patent stocks contribute to the market value of firms that can be derived from the stock price at which the company's shares are traded. Both R&D investments and patent stocks affect future cash flows and, if discounted at an appropriate rate and summed up, the current market value of a company. R&D efforts and patents impact future cash flows because they are associated with growth expectations regarding future performance (Hall, 2009; Deng et al., 1999). Recent literature revealed similar results and highlight that patents *"add information above and beyond that obtained from R&D, as one would expect if they measure the 'success' of an R&D program."* (Hall et al., 2001: 6)

Existing studies analyzing the contribution of patent stocks to firm market values generally assumed intangible assets to be *positive*. This is rooted in the fact, that patents can be counted (i.e., producing *positive* numbers) and patent stocks can be compared (i.e., comparing *positive* numbers). Concerning research-driven firms, Hsu and Ziedonis (2008) find that patent portfolios positively impact the amount of financing through venture capitalists. Similarly, Haeussler et al. (2008) point out that venture capitalists consider the patent stocks of innovative start-ups and finance new ventures faster if they have patents of high quality. This is consistent to Morrow et al. (2007) arguing that patent stocks can be viewed as positive signals for entrepreneurs and investors. However, assessing R&D *mis*performance simply with R&D investments and patents is, by definition, not possible. Therefore, in this study we seek to assess the valuation of patent stocks in the context of adverse

events by explicitly focusing on NPD failures which are frequent in practice and can generally not be avoided in many innovation-driven industries.

Research on new product development management has found that NPD failures lead to a substantial devaluation of firms in financial markets (De Carolis et al., 2009; Girotra et al., 2007). That is, because the company and its investors have set expectations about the successful development of a potential new product; however, as it has not met these expectations, a substantial drop in the firm market value results. This decline is rooted in the mechanics of financial markets, because the firm market value is, according to the Efficient Markets Theory (Fama, 1970), defined as the sum of all discounted future cash flows: if future cash flows are expected to decline, the current value of the firm simultaneously decreases. Besides the devaluation after NPD failure, we propose that large patent stocks lead to increased value drops due to highly disappointed investors' expectations. Patents generally inform investors, first, about well-functioning R&D processes (e.g., Pakes and Griliches, 1980; Scherer, 1983) and, second, about the protection of future cash-flows from protected inventions (e.g., Besen and Raskind, 1991). In case news about NPD failure disseminate in the market, investor will revise their perceptions so that patent stocks act as leveraging the magnitude of the devaluation. We refer to this *expectation effect* by proposing that the more patents an innovatice company holds, the larger this leverage and, with it, the loss in firms' market value after NPD failure. Thus,

> *H1: The larger a firm's patent stock the larger the decline in market valuation after NPD failure.*

So far, we discussed the effect of patents for ongoing NPD projects. In addition to that, they can also affect parallel and potential new NPD projects based on the underlying invention. Therefore, patents do not inevitably lead to an increase of the devaluation after adverse events. Instead, patents may also inform investors about the way the company has spread its NPD risk: imagine a firm simultaneously working on several projects. If one of these NPD projects fails, the other existing projects may counterbalance the negative perception of investors leading to a weakened devaluation. In this way, a large patent portfolio may also reflect diversified R&D efforts signaling that the firm has diversified its NPD risk. In that case, a broad patent portfolio may reduce the degree of devaluation because larger patent stocks can have a *buffering effect*.

In this context, George (2005) highlights the positive impact slack resources have on firm performance after environmental shocks since slack improves the firms' strategic flexibility. De Carolis et al. (2009) extend this finding and analyze how new ventures can prepare themselves for an adverse event. Focusing on biotechnological NPD failures, they show that, in order to weaken negative valuation effects of adverse events, new ventures should seek to build up unique assets such as strategic alliances or a promising product pipeline. Conversely, generic assets such as cash available are not capable of buffering from negative effects. This is consistent with Morrow et al. (2007) investigating companies that have failed to meet investors' expectations. Results show that difficult-to-imitate strategies recombining the firm's stock of resources to create new products are positively related to firm recovery. Patents by definition protect difficult-to-imitate

intangibles since patent protection is only granted for non-obvious and novel inventions. We therefore postulate that the impact of patent counts on devaluation after NPD failure is U-shaped in nature. In other words, until a certain threshold value, the number of patents held by a company increases the degree of devaluation (*expectation effect*). Above this threshold of patent portfolio size, each marginal patent decreases the drop in firm market valuation (*buffering effect*). Thus,

> *H2: There is a U-shaped relationship between the size of a firm's patent stock and the decline in market valuation after NPD failure.*

We further argue that the proposed U-shaped relationship between patent counts and firm market value after NPD failure can substantially vary with firms' R&D strategy. This is reasonable to argue as, for example, the average age of the firm's patent stock or different strategies of patent protection (e.g. blocking strategies, or using patents as bartering chips, see Blind et al., 2009) may significantly influence the effect patent stocks have on firm market values after NPD failure announcements. Strategy scholars have made important contributions by showing that both expectation formation and buffering potential can substantially vary for different types of companies (De Carolis et al., 2009; Girotra et al., 2007; Guedj and Scharfstein, 2004).

Our study focuses on how a company's R&D strategy may impact its patent quality and structure and, consequently, firm market values after NPD failure. We draw on De Carolis et al. (2009) and Deng et al. (1999) who show that a firm's level of R&D intensity (i.e., the R&D expenditures-to-sales ratio) is strongly

associated with growth expectations by external investors. That is, because the level of R&D intensity informs investors about the innovativeness, the market potential and the new product pipeline of a research-intensive firm (Rzakhanov, 2004). We follow this line of reasoning and argue that firms' R&D intensity is one of the best publicly available and objective indicators capable of differing between several company R&D strategies within the biotechnology sector.

Recent work by Xu et al. (2007) shows that high levels of R&D intensity indicate that a company spending a comparably high amount of money for developing new products signals to external investors that those firms have a substantial stock of technology-based intangibles. With a growing stock of knowledge assets, the firm's absorptive capacity – their ability to identify and acquire knowledge from external partners as well as to understand and apply this knowledge for its own use – increases (Zahra and George, 2002; Cohen and Levinthal, 1990). Consequently, a firm dedicating large funds to R&D might be positively evaluated by investors since that firm may better be able to overcome shocks such as NPD failures than a firm with parsimonious R&D budgets. Additional to the proposed U-shaped relationship between patent counts and the devaluation effect after NPD failure, we expect that a firm strategy of high R&D intensity will weaken potential devaluation effects. Thus,

> *H3: The U-shaped relationship between the size of a firm's patent stock and the decline in market valuation after NPD failure is more pronounced for firms with high R&D intensity than for firms with low R&D intensity.*

## 5.3 Methodology and data collection

### *5.3.1 Sampling*

To test our set of hypotheses we chose the biotechnology industry in the United States as a research frame. This particular industry is well suited for our investigation because it is an innovation-driven sector where risky new product development is critical for firm success (Rothaermel and Deeds, 2006; Sharma and Lacey, 2004). Furthermore, the development process for drugs is clearly defined, such that NPD failures can be well determined (Girotra et al., 2007; Guedj and Scharfstein, 2004). At the beginning of NPD processes, there is basic research in the lab, followed by pre-clinical studies and three clinical stages to ensure both the safety and effectiveness of the NPD candidate with human beings. Finally, each new drug must complete the NDA review process before the FDA can classify it as "approvable" for the American market (Evans and Varaiya, 2003). After each of these stages, firms have to decide whether to continue with the next stage or to terminate development (Abrantes-Metz et al., 2005; Guedj and Scharfstein, 2004). Concerning patents, this industry is well suited for our analysis since protection of R&D outcomes is a fundamental issue for firms in this sector. For biotechnology companies, sound patent protection is of utmost importance because R&D costs of developing new product candidates are – due to the duration and the requirements of the NPD process – high although the costs of manufacturing new drugs are low (Chen and Chang, 2009). Only products protected by patents allow these companies to recover the large funds they have previously invested in R&D. Another reason is rooted in the way inventions (i.e., technology) are linked to

products: each potential new product can generally be protected by one patent or only few patents. This is in contrast to, for example, the electronics industry where one product (e.g., a cell phone) needs to be protected by dozens or even hundreds of patents. Put differently, the biotechnology sector is based on discrete technology, whereas electronics, for example, is associated with complex technology (von Graevenitz et al. 2008)

Our sample consists of publicly traded biotechnology firms that were included in the NASDAQ Biotechnology Index during the period 1994 to 2008. We explicitly focus on NPD failures that occurred during the clinical stages and the FDA approval phase because (i) announcement of these failures must be published, and (ii) the impact of NPD failures on firm market value is more substantial than, for example, failures in the research or pre-clinical stages (Himmelmann and Schiereck, 2009; Girotra et al., 2007). Clinical trial data were collected from the Recombinant Capital Database, a database of biotechnology firm press releases that has been commonly used for studies in this field before (De Carolis et al. 2009; Rzakhanov, 2004). Additionally, we used the EPO Worldwide Patent Statistical Database (EPO PATSTAT) to obtain the patent data for all companies in our sample. This database is available under license from the OECD-EPO Task Force on Patent Statistics and contains all worldwide patent applications and patent publications (OECD, 2009). For each observation in our data set (i.e., for each NPD failure), we collected all patents of the company to determine the size of each firm's patent portfolio at the date of failure. Moreover, we used the technological linkages between the patents (i.e., patent citations) to approach the average patent

quality of each portfolio. Finally, financial data were gathered from The Wall Street Journal, MarketWatch, LexisNexis, and the companies' web pages.

Our initial data set covered 92 biotechnology firms which experienced 593 NPD failures during the years 1994 and 2008. We had to drop a total of 306 NPD failures because full information of the exact failure date or the failed product's stage was not available. Importantly, failures listed in the ReCap database as having occurred on the first day of a month may indicate failures for which only the month, but not the accurate day, could correctly be identified by ReCap.[6] After cross-checking all failure dates with the companies' press releases and SEC filings, we had to drop 34 data points for which such cross-validation was not successful. Moreover, 87 NPD failures were excluded from our sample because financial data at the time of failure were not available. Finally, we had to drop 12 NPD failures since data on the firms' patent stock at the time of failure was not available. Our final data set consists of 154 NPD failures from 66 biotechnology firms. At the time of failure firms were, on average, 15 years old and had about 1,512 employees.

### *5.3.2 Measures*

*Dependent variable*. The dependent variable of this event study, Cumulative Abnormal Return, operationalizes the financial impact NPD failures have on market valuation of biotechnology firms (Girotra et al., 2007; McWilliams and Siegel, 1997). Following previous research on event study methodology (Farber

[6] Personal e-mail communication with ReCap employees.

and Hallock, 2009; Nixon et al., 2004; Brown and Warner, 1985), we control for potentially confounding, firm specific events by choosing a comparatively short event window around the exact date of the NPD failure. Further, in order to control for confounding industry-wide events we use the NASDAQ Biotechnology Index as the benchmark for calculating market-adjusted abnormal returns (Hendricks and Singhal, 2008; Campart and Pfister, 2007). We measure the CAR as the relative difference between the price of the index and the firm stock price during a three-day event window (Girotra et al., 2007; McWilliams and Siegel, 1997) including the day prior to, the day of, and the day following the announcement of the NPD failure, i.e. CAR(-1,+1). Note that we define all event windows with respect to trading days in the United States. Finally, to check the robustness of our results, we also calculated a longer event window, i.e. CAR(-2,+2). Our results remain stable for this longer event window (see also below).

The mean CAR(-1,+1) is -13.6%, indicating that during this period the firm's market value decreased on average by 13.6% relative to the benchmark index. We find similar results for CAR(-2,+2), i.e. -14.2%, again indicating that in our sample the market reaction to NPD failures is strongly negative. This is consistent with prior findings by Buerger et al. (2010), De Carolis et al. (2009), Girotra et al. (2007), and Sharma and Lacey (2004).

*Independent variables.* First, we measure patent counts by the number of patent families which consist of at least one issued patent to account for the geographical territory the invention is protected in (van Zeebroeck et al., 2009; Lanjouw et al., 1998). A patent is a geographically limited intellectual property

right which grants protection for the subject-matter in the territory the patent has been filed. Thus, if a company seeks protection in a larger territory – for example, if the underlying invention is deemed to be important – the company needs to apply for protection in several countries (Putnam, 1996). Measuring the total issued patents would therefore overestimate the inventive efforts of a firm. To tackle such seemingly inflated amounts of patents, we measure the number of patent families (van Zeebroeck et al. 2009; Lanjouw et al. 1998). A patent family is a group of patents all relying on the same invention and, thus, approaches the inventive efforts of a firm more appropriately. As the number of patent families is rather skew and only few firms show an intense patenting activity – which can also be explained by the size of the company – we for the remainder of this study used the logarithm of patent families to encounter the skew distribution.

As a variable reflecting firms' R&D strategy, we measure a firm's *R&D intensity*, operationalized as R&D expenses per employee (Sher and Yang, 2005; Baysinger et al., 1991; Graves, 1988). Another often used proxy for R&D intensity, R&D per sales revenues (Deng et al., 1999; Cohen and Klepper, 1992), is not defined for zero revenues. Since many young biotechnological firms do not generate any revenues due to the lengthy NPD cycles, using this measure would lead to substantial sample selection bias.

*Control variables*. We include various control variables in our analysis known or expected to influence firm CAR. The first set of control variables relate to firm characteristics. First, we control for *firm age* since investors may assess the failure risk of younger ventures higher due to their resource constraints (Zheng et

al., 2010; George, 2005; Deeds and Hill, 1996). Firm age is operationalized as the number of days from firm inception to its failure (De Carolis et al., 2009). Second, we control for *firm size* by including the logarithm of the total numbers of employees. Guedj and Scharfstein (2004) show that firm size signals better opportunities to access and control resources, suggesting that larger firms might generally have a better capability to buffer the impact of NPD failures. Third, we control for *firm cash* representing the firms' financial capabilities. Since in our data cash is strongly correlated with firm size, we follow prior research (e.g., Beatty, 1995) and use the firm size corrected ratio of cash, which is cash divided by the total number of employees.

The next set of control variables refers to the characteristics of the failed NPD project. First, we control for *development stage* since existing studies (Himmelmann and Schiereck, 2009; Rzakhanov, 2004) show that NPD failure happening during late stages typically lead to sharper drops in firm market value compared to early stage failures. To simplify analysis, we consider only two stages and label Phase I and Phase II as 'early stage' and Phase III and the NDA approval phase as 'late stage'. Stage is contrast-coded with a value of -0.5 when the NPD failure occurred in early stage, and +0.5 otherwise. Our final sample consists of 84 early stage and 70 late stage NPD failures. Furthermore, investor reactions to NPD failure can be influenced by simultaneous announcements of bad and good news. We expect that especially good news regarding other late stage NPD projects can significantly impact firm market values after NPD failure. We therefore include

two variables, *good news early* and *good news late*, to count the number of simultaneously announced good and bad news.

The last two control variables refer to patent quality. We use two established patent value indicators to proxy the average quality of patents in a portfolio: backward citations and forward citations. As a patent is filed, other related patent publications are listed on the search report publishes by the patent examiners of patent offices. Such references indicate which previous filed patents are related to the patent application in question; and also, which of those might conflict with it. Corresponding to scholarly articles referencing previous research, *backward citations* reflect references to other previously filed patents. This value indicator has been found to be positively correlated with firm values (Lanjouw and Schankerman, 2004; Harhoff et al., 2003). Correspondingly, *forward citations* represent those citations which a patent collects from subsequent filings after the publication of its search report. Research also found these forward citations to be highly positively related to firm values (Hall et. al, 2005; Trajtenberg, 1990). Since we do not consider single patents, but patent families, we need to aggregate both backward and forward citations and, thus, obtain family-to-family backward and forward citations for each patent family. Following other research (e.g., Hall et al., 2007), the number of citations are then pooled across all patent families on the firm level to arrive at metrics that correspond to our NPD failure event dataset.

## 5.4 Results

### *5.4.1 Descriptive statistics and correlations*

Table 7 shows the descriptive statistics and correlations for the variables in our sample (for the original as well as for the logarithm of the variable where appropriate). The correlation table shows a strong positive association between firm size and patent counts as well as a moderate negative association between firm size and R&D intensity. Both observations are not surprising since larger firms typically invest relatively less in R&D as compared to small firms (Rzakhanov, 2004) and tend to have larger patent stocks (Chen and Chang, 2009). Furthermore, we find – as expected – that older firms tend to be larger (Guedj and Scharfstein, 2004).

Regarding our dependent variable CAR(-1,+1), we observe negative valuation effects for firms announcing NPD failures, i.e. -13.6% which is consistent with previous studies (De Carolis et al., 2009; Rzakhanov, 2004). In line with prior work, we also find that NPD failures in late stages lead to larger drops in firm market values (Buerger et al., 2010; Himmelmann and Schiereck, 2009) and that firm specific resources can mitigate the negative consequences after NPD failure (De Carolis et al. 2009; Girotra et al., 2007). The significant coefficients for good news support our decision to control for this effect.

| Variables | Mean | S.D. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 CAR (-1,+1) | -0.14 | 0.22 | 1 | | | | | | | | | | | |
| 2 Firm age | 14.88 | 5.40 | 0.10 | 1 | | | | | | | | | | |
| 3 Firm size | 1.512 | 3273 | 0.24** | 0.39*** | 1 | | | | | | | | | |
| 4 Firm size (log) | 6.02 | 1.55 | 0.43*** | 0.30*** | 0.74*** | 1 | | | | | | | | |
| 5 Cash (size-corrected) | 0.28 | 0.29 | -0.15+ | -0.00 | -0.20* | -0.22** | 1 | | | | | | | |
| 6 Development stage | 0.09 | 1.00 | -0.27*** | -0.12 | -0.01 | -0.09 | -0.13 | 1 | | | | | | |
| 7 Good news (early) | 0.40 | 0.73 | -0.19* | 0.00 | -0.07 | -0.01 | -0.11 | -0.18* | 1 | | | | | |
| 8 Good news (late) | 0.24 | 0.47 | 0.28*** | -0.08 | 0.11 | 0.10 | -0.02 | 0.20* | 0.00 | 1 | | | | |
| 9 Backward Citations | 2.20 | 2.22 | -0.17* | -0.09 | 0.03 | -0.04 | -0.05 | -0.03 | -0.00 | -0.11 | 1 | | | |
| 10 Forward Citations | 0.12 | 0.14 | 0.12 | 0.08 | 0.07 | 0.08 | 0.12 | -0.05 | -0.01 | -0.06 | 0.06 | 1 | | |
| 11 R&D intensity | 0.25 | 0.16 | -0.36*** | -0.10 | -0.27*** | -0.56*** | 0.20* | 0.01 | -0.03 | -0.10 | -0.05 | -0.26* | 1 | |
| 12 Patents | 0.39 | 0.74 | 0.21** | 0.18* | 0.74*** | 0.67*** | -0.14+ | -0.08 | 0.04 | 0.11 | 0.04 | 0.06 | -0.20* | 1 |
| 13 Patents (log) | 4.55 | 1.83 | 0.18* | 0.33*** | 0.56*** | 0.73*** | -0.11 | -0.19* | 0.04 | -0.08 | 0.05 | -0.14+ | -0.29** | 0.72*** |

N=154
Significance levels: + p<0.10, * p<0.05, ** p<0.01, *** p<0.001

**Table 7: Descriptive statistics and Pearson correlation coefficients**

*5.4.2 Results of the event study analysis*

To test our three hypotheses, we use hierarchical clustered moderated regression analysis controlling for within-firm error correlation (Models 1 to 5). Specifically, we run a pooled OLS regression analysis and estimate standard errors that are robust with respect to heterogeneity and intra-cluster correlation (Wooldridge, 2002). This method allows us to account for the hierarchical nature of our data since some companies in our sample experienced more than one NPD failure. For estimating the regression models, we standardized all continuous variables that are part of either interaction terms or squared terms. Table 8 summarizes the regression results. We report estimated coefficients and robust standard errors and the models' R-squared, F-values and fit indices. Furthermore, we report the increase in explained variance ($\Delta R^2$ and its significance level) for control variables, direct effects, and moderation effects. To test potential concerns about multicollinearity, we calculated Variance Inflation Factors, which are below 4.9 for the full model, which is an accepted level indicating that multicollinearity is not an issue in our sample (Rothaermel and Hess, 2007; Hair et al., 2005). Furthermore, we test the normality of residuals for the final model; D'Agostino's K-square goodness-of-fit measure of departure of normality (D'Agostino et al., 1990) cannot reject the null hypothesis of normality of the residuals ($\chi^2$=3.13, p=0.209).

| **Model** | **1** | | **2** | | **3** | | **4** | | **5** | |
|---|---|---|---|---|---|---|---|---|---|---|
| Dependent variable | CAR(-1,+1) | | CAR(-1,+1) | | CAR(-1,+1) | | CAR(-1,+1) | | CAR(-2,+2) | |
| Constant | -0.374 | (0.075)*** | -0.538 | (0.096)*** | -0.517 | (0.105)*** | -0.530 | (0.101)*** | -0.508 | (0.105)*** |
| *Control variables* | | | | | | | | | | |
| Firm age | -0.001 | (0.002) | 0.000 | (0.002) | 0.000 | (0.002) | 0.001 | (0.002) | 0.001 | (0.002) |
| Firm size | 0.039 | (0.010)*** | 0.064 | (0.013)*** | 0.059 | (0.015)*** | 0.060 | (0.015)*** | 0.054 | (0.016)** |
| Cash (size-corrected) | -0.072 | (0.047) | -0.061 | (0.045) | -0.060 | (0.045) | -0.061 | (0.048) | -0.069 | (0.049) |
| Development stage | -0.064 | (0.016)*** | -0.067 | (0.017)*** | -0.067 | (0.017)*** | -0.067 | (0.017)*** | -0.064 | (0.018)*** |
| Good news, early | 0.038 | (0.020)+ | 0.041 | (0.021)+ | 0.040 | (0.021)+ | 0.039 | (0.020)+ | 0.030 | (0.021) |
| Good news, late | 0.131 | (0.033)*** | 0.118 | (0.030)*** | 0.113 | (0.030)*** | 0.110 | (0.029)*** | 0.104 | (0.028)*** |
| B-citations | -0.015 | (0.010) | -0.013 | (0.010) | -0.012 | (0.010) | -0.010 | (0.011) | -0.007 | (0.013) |
| F-citations | 0.143 | (0.062)* | 0.071 | (0.062) | 0.039 | (0.089) | 0.115 | (0.082) | 0.161 | (0.084)+ |
| R&D intensity (RD) | -0.029 | (0.019) | -0.025 | (0.018) | -0.030 | (0.020) | -0.065 | (0.026)* | -0.075 | (0.027)** |
| *Patent counts* | | | | | | | | | | |
| Patent counts (log) (PAT) | | | -0.049 | (0.021)* | -0.045 | (0.022)* | -0.030 | (0.023) | -0.018 | (0.024) |
| *Quadratic effect* | | | | | | | | | | |
| PAT x PAT | | | | | 0.009 | (0.014) | 0.006 | (0.012) | 0.005 | (0.010) |
| *Moderation by R&D intensity* | | | | | | | | | | |
| PAT x RD | | | | | | | 0.021 | (0.015) | 0.022 | (0.014) |
| PAT x PAT x RD | | | | | | | 0.032 | (0.010)** | 0.034 | (0.010)** |
| Observations (clusters) | 154 | (66) | 154 | (66) | 154 | (66) | 154 | (66) | 154 | (66) |
| R-squared (F-test) | 0.395 | (6.32)*** | 0.413 | (10.68)*** | 0.415 | (8.88)*** | 0.449 | (11.20)*** | 0.432 | (12.61) |
| Δ R-squared (F-test) | | | 0.018 | (5.43)* | 0.002 | (0.41) | 0.034 | (6.14)** | | |

**Note:** Heteroscedasticity- and cluster-robust standard errors reported in parentheses. Patent counts and R&D intensity were standardized.
Significance levels: *** p<0.001, ** p<0.01, * p<0.05, + p<0.10

**Table 8: Hierarchical Moderated Regression Analysis (OLS)**

Hypothesis 1 suggests that in case of NPD failure, patent counts negatively affect the market valuation of innovatice firms. Model 1 includes control variables only and is statistically significant ($p<.001$). It explains 39% of the variance in CAR(-1,+1). In Model 2, which is also statistically significant ($p<.001$), we add the firm's patent counts. This second model explains 41% of the variance, which represents a significant increase ($p<.05$) as compared to Model 1. The coefficient of patent counts is significantly negative ($\beta_{PAT}$=-0.05 with $p<0.05$) providing support for Hypothesis 1.

Hypothesis 2 suggests that the relationship between patent counts and the firm market value is U-shaped in nature. Model 3 tests this hypothesis by including the quadratic term of patent counts. The model is statistically significant ($p<.001$) and the quadratic term is positive as suggested. However, the coefficient is not significant ($\beta_{PATxPAT}$=0.01 with p=n.s.) and the model does not explain significantly more variance than Model 2, which only includes a linear term of patent counts. Therefore, we cannot generally support Hypothesis 2.

Hypothesis 3 suggests that the proposed U-shaped relationship between patent counts and the firm market value is moderated by the company's R&D strategy in a way that the U-shaped relationship hypothesized in Hypothesis 2 is stronger for R&D intensive firms and weaker for firms with low R&D intensity. Model 4 tests this moderation effect. We add the interaction terms between the firms' level of R&D intensity and patent counts, which included the linear as well as the quadratic term. This model is statistically significant ($p<.001$) and the variance explained by this model, 45%, is significantly larger compared to Model

3, which does not include the moderation effects. A joint test of the moderation effects being zero can be rejected ($\beta_{PATxRD}$ =0 and $\beta_{PATxPATxRD}$ =0, F(2,65)=6.14, p=0.004).

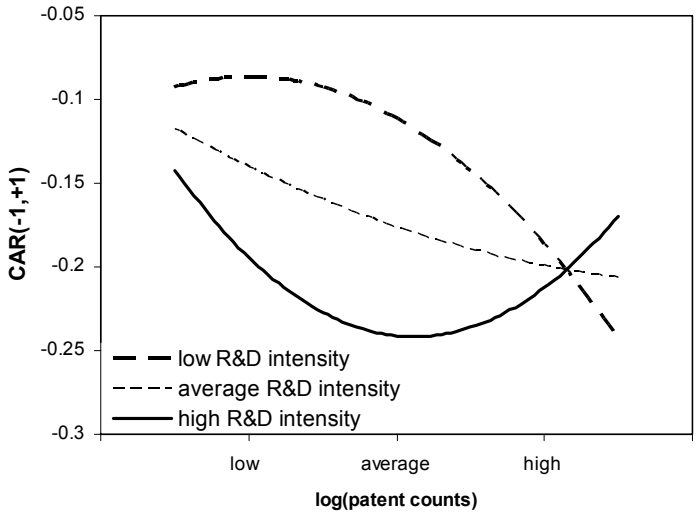


**Figure 8: Interaction effects of the firm R&D intensity with the number of patents**
**Source: Own illustration**

To ease the interpretation of the moderation effect, Figure 8 plots the dependency between patent counts and CAR(-1,+1) predicted for firms with high respectively low levels of R&D intensity (operationalized as mean minus or plus, respectively, one standard deviation). We also calculate the estimated linear and squared effects independently for low and high R&D intensity (minus or plus, respectively, one standard deviation), which basically describe the shape of the two lines plotted in Figure 8 allowing a more statistically grounded interpretation of the plot. We find that for high R&D intensity, the linear effect disappears ($\beta_{PAT}+\beta_{PATxRD}$=-0.01, s.e.=0.03, p=0.786). Thus on average, high R&D intensive firms do not suffer from more patents. However, there is a significantly positive

quadratic effect ($\beta_{PATxPAT}+\beta_{PATxPATxRD}$=0.04, s.e.=0.02, p=0.041), indicating that for smaller patent counts, the effect is negative, while for larger patent counts the effect is positive. This is consistent with our arguments developed for Hypothesis 2. However, consistent with Hypothesis 3, we find that for low R&D intensity firm the effects are different. We observe a significantly negative linear effect ($\beta_{PAT}-\beta_{PATxRD}$=-0.05, s.e.=0.02, p=0.010), which means that such firms do on average suffer from more patents. We also observe a significantly negative quadratic effect ($\beta_{PATxPAT}-\beta_{PATxPATxRD}$=-0.06, s.e.=0.02, p=0.001), suggesting that the negative effect of more patents even increases for larger patent stocks. To summarize, we find substantial support for a moderation of R&D intensity on the effect of patent counts, and these effects are consistent with our reasoning for Hypothesis 3: the buffering effect is stronger, and in fact only appears, for firms with high R&D intensity.

Following previous studies in this field (e.g., De Carolis et al., 2009; Girotra et al. 2007), we estimated our final model also for a larger event window. Model 5 in Table 8 reports results for a five-day event window, i.e. CAR(-2;+2). We find that all our results are robust in term of the size of the relevant coefficients and their significance, respectively.

**5.5 Discussion and conclusion**

How do patent stocks affect market values of innovative firms after NPD failures? We examine this question by drawing on existing NPD and patent literature to shed new light on the role of patents in the context of NPD failure. Although prior studies made important contributions on how patent stocks affect

firm market values, we add to this literature by examining their impact on market values in case of adverse events. Our results show that patent counts negatively impact market values of innovative companies after NPD failure. This effect is consistent to existing patent literature demonstrating that firms with large patent portfolios raise significantly higher expectations by investors compared to firms with only few patents at hand (Hsu and Ziedonis, 2007; Hirschey et al., 2001). Consequently, in case of adverse events such as NPD failure, investors' expectations are disappointed leading to substantial drops in firm market values. We show that this negative expectation-based effect can be complemented by a buffering effect, where large patent stocks can also provide the potential to overcome NPD failures. The patent stock's potential for such recovery, however, depends on a firm's R&D strategy. We explain a significant share of variance in investor reaction to NPD failure. As follows, we discuss three implications of this study.

### *5.5.1 Theoretical implications for patent literature*

Existing patent literature is relatively silent on the effect patent stocks have on firm values during adverse events. Much of the work has focused only on how patent counts and patent quality can generally contribute to values of innovative firms in financial markets (Hall, 2009; Chen and Chang, 2009; Lanjouw and Schankerman, 2004). However, this strand of literature neglected the effect patent stocks have on firm market values in the context of failures. Indeed, to the best of our knowledge, only few studies have been published that explicitly took into account that patents are perceived as quality signals by investors to build up

expectations about a firm's future potential. Hsu and Ziedonis (2007) show the extent to which patenting activities of innovative firms alter investors' estimates of its economic value. Using data on the patenting activities of 370 U.S. semiconductor firms, they find a substantial positive effect of patents on investors' estimates of firm value. Hirschey et al. (2001) examine the link between patents and market value by using a sample of 1.290 company observations over the period from 1989 through 1995. Results show that patent quality positively affects market values and suggest that investors perceive a positive relation between the scientific merit of patent output and the value created by R&D expenses. Deng et al. (1999) examine the ability of patent-related measures to reflect innovative firms' growth potential. Drawing on a sample of 388 firms from four different sectors they highlight that patent counts and patent quality are associated with subsequent stock returns. They suggest that the information conveyed by these measures is not fully reflected in market values in a timely manner. We complement to patent literature by investigating how firms' patent stocks may impact the negative market response after NPD failure, and how this effect is contingent on the firms R&D strategy.

### *5.5.2 Theoretical implications for NPD literature*

Our findings are consistent with existing NPD literature suggesting that firm specific characteristics can explain heterogeneity of event severity across firms. Much of this literature has focused on the impact tangible resources have on market valuation during adverse events. De Carolis et al. (2009) investigate how firm characteristics can mitigate negative consequences after NPD failure announcements. Using data on 57 biotechnology firms experiencing 104 drug

terminations they show that strategic alliances, product pipelines, technological competence, and high level of R&D intensity can buffer adverse events. Girotra et al. (2007) examine the valuation of NPD projects by conducting an event study on 169 failures of biotechnological firms. Focusing on Phase III failures, they explain heterogeneity in NPD project valuation based on interactions with the stage of the failed NPD project and other product candidates suggesting that portfolio-level interactions should be taken into account when explaining investor reactions to failures. Morrow et al. (2007) analyze data on 178 manufacturing firms that have failed to meet investors' expectations. Results show that difficult-to-imitate strategies recombining firms' existing stock of resources are positively related to firm recovery. We draw on these findings and add to the NPD literature by providing one of the first empirical studies that examine the impact intangible assets have on firm market values after NPD failures.

Regarding the proposed U-shaped relationship between patent counts and market values our data reveals no general support. However, with respect to the impact firm specific characteristics can have in this context, our results show that the impact of patent counts on firms' market values significantly varies depending on the company's R&D strategy that can be endogenously influenced by the firms' managers. This finding complements prior work by De Carolis et al. (2009) and Deng et al. (1999) suggesting that investors' expectation are, at least partly, build on the company's level of R&D intensity. They argue that stock prices reflect the information embedded in R&D intensity and that investors' expectation about positive NPD outcomes are significantly higher for companies with a high level of

R&D intensity. Our results complement these arguments by showing that for high R&D intensive firms, their market values in financial markets first decrease and then increase with a higher number of patent counts. In other words, for high R&D intensive firms, large patents stock can substantially buffer negative consequences after NPD failure. In contrast, for low R&D intensive firms, the effect of more patents is still negative. It appears that patents from R&D intensive firms may indicate more opportunities for future NPD processes and, in addition to that, a higher likelihood for successful firm recovery leading to less sharp drops in market values after NPD failure. While this is just an *ex post* interpretation, future research should test this explanation more thoroughly.

Finally, our study adds to the emerging literature demonstrating that more firm resources are not necessarily beneficial for the company. For example, scholars have highlighted that there is a curvilinear relationship between organizations financial slack and firm performance since managers tend to deploy too much money inefficiently (George, 2005; Leonard-Barton, 1992). Our findings indicate that patent counts enhance investors' expectations about positive NPD outcomes and future performance, but they may also lead to substantial drops in firm market values in case of NPD failure when these expectations become disappointed. However, it appears that a large patent stock can raise new expectations regarding a successful recovery from NPD failure because large patent stocks seem to be valued as being the fundament on which new products and future returns are build. Finally, an appropriate stock of patents is beneficial to overcome NPD failures and to diminish negative consequences of adverse events.

### *5.5.3 Practical implications*

Our findings have implications for practice, especially for mangers of innovative firms since they enable them to better understand the market valuation consequences of potential NPD failures. Specifically, our results highlight the influence that investors' perceptions of intangible resources have on market values during NPD failures, and that this impact depends on firm specific characteristics such as the firm's R&D strategy. It appears that investors systematically use intangible asset stocks of innovative firms to build expectations regarding future cash flows and returns. Managers should be aware of existing knowledge asymmetries between them and external investors. If managers are able to better understand the processes at work it seems that they can use patents to balance investors' expectations regarding positive and negative NPD outcomes. Following this reasoning implies that limiting investors' expectations to avoid exaggerated firm market values *ex ante* and suffering not too much from NPD failures *ex post* are two sides of the same performance coin. Moreover, both researchers and practitioners should be aware of the face that neither R&D nor patents are ends in themselves but instead are means to develop attractive new products. If such developments fail, knowledge assets that have been built up cannot be monetarized. In our world with dramatically increasing annual patent application volumes from year to year (van Zeebroeck et al. 2009), it is thus even more important to assess the relationship between patents and successful and unsuccessful new products.

### *5.5.4 Limitations and future research*

Despite the findings pointed out above, this study does not come without any caveats. Yet, the limitations we identify in turn also provide new avenues for future research. The first limitation of this study is limited to the fact that in this study, we only included firms where NPD failures were observable. Subsequently, we added patent portfolios metrics. Unfortunately, it was not possible to exactly determine which patents within corporate portfolios concern the NPD failure at hand and which patents protect other inventions unrelated to the failed NPD project. We suggest that connecting the NPD failure to the concerned patents would add further value, and defer such further inquiries to future research.

Finally, our arguments for Hypothesis 3 refer to the idea that a firm's R&D strategy affects the degree to which the firm's patent stock offers opportunities for further R&D projects and subsequent NPD success. This characteristic of the patent stock has, however, not been tested in this study. As a consequence (and also as a robustness check of our results), we have considered forward citations as an indicator of such potential for further research. In contrast to previous research, which considers forward citations as a quality indicator (e.g. Hall et al., 2005; Harhoff et al. 2003), one could also argue that the more other firms cite a patent stock, the more the research opportunities offered by this stock are already exploited (for complex technologies see von Graevenitz et al., 2008). We run the same moderation analysis for forward citations as we have run for R&D intensity. Results, which are available on request (see Appendix), are consistent with our intuition, i.e. firms with less forward citations show a U-shaped relationship

between patents and abnormal returns. Because indicators of multicollinearity issues marginally exceed accepted thresholds, this study does not focus on this dependency. However, the fact that this analysis also supports our previous conclusions makes us confident that our findings exhibit a high degree of robustness. Yet clearly, future research is required to test the robustness of our conclusion for other variables, other industries, and different methods.

In conclusion, this study shows that patent stocks substantially affect firm market values after NPD failure announcements. Although we cannot claim that this intangible resource influences the true value of the company, our results show that it impacts investor perceptions of the firm that experienced such kind of adverse event. Whether this perception is realistic or not is not subject of this study and, furthermore, provides a fruitful area for future research. We extend existing NPD and patent literature by demonstrating that in context of NPD failures patent counts negatively affects firm market values. Moreover, we show that the expectation-based negative effect of patent counts is U-shaped for companies with a firm strategy of high R&D intensity indicating a substantial impact of firm specific strategies in this context. We further emphasize that interaction effects should be taken into account when explaining investor reactions to failure.

# 6 Conclusions and new avenues for research on new product development failure and their consequences

In this thesis I present four event studies that investigate important and cutting-edge issues surrounding new product development failure and its consequences for market values of innovation-driven firms. Although existing literature demonstrates that NPD failure harms some companies more than others, in this thesis I seek to study which factors, specific to a firm, impact this variance in investor reactions to NPD failure. Moreover, I investigate how innovative firms can foster or mitigate financial consequences when they announce that promising NPD projects have failed to achieve desired milestones. Using a unique dataset of publicity traded US biotechnology firms experiencing NPD failures during the period of 1994-2008, my four different event studies provide insights to management scholars, firm managers, and biotech investors. The results of these studies show that investor reactions to NPD failure are more complex than many previous studies have assumed, and that firm resources and capabilities at different organizational levels interactively impact these reactions. In Section 6.1 I will briefly summarize the key findings of this thesis' studies as well as the contributions it makes to the literature. Then, in Sections 6.2, I conclude with suggestions for new avenues for future research on new product development failure and the financial consequences for innovative firms.

## 6.1 Summary of results and contributions

A substantial body of new product development literature broadens our understanding on how positive NPD outcomes impact market values of innovative firms (e.g., Himmelmann and Schiereck, 2009; Sarkar and De Jong, 2006; Sharma and Lacey, 2004). However, studies investigating how negative NPD outcomes, such as NPD failure, impact market value of innovative firms are still rare. Due to the frequency of NPD failures in many innovation-driven sectors and the fact that companies often loose many million US$ when they announce NPD failures, it is important to investigate these adverse events and the consequences for innovative firms. While prior studies highlight that the severity of NPD failures differs across firms (e.g. De Carolis et al., 2009; Napshin and De Carolis, 2007), it is also important to understand why NPD failures harm market values of some firms more than others. Therefore, the goal of this thesis is to provide more insight into how investors react to NPD failures.

In chapters 2, 3, 4, and 5, I link different literature streams, including the resource based view of the firm (chapter 2), Upper Echelon theory (chapter 3), news announcement (chapter 4), and patent literature (chapter 5) to investor reactions after NPD failure announcements. There are two competing theoretical perspectives in the literature on how firm specific resources and capabilities can impact firm market valuation after NPD failure and I integrate both perspectives in all chapters. First an *ex ante perspective* argues that investors' success expectations of NPD outcomes before the failure event determine the decline in firm market value in case NPD projects actually fail (Sharma and Lacey, 2004; Kellogg and

Charnes, 2000). In contrast, an *ex post perspective* suggests that investor reactions to NPD failure are rather driven by their perceptions of the company's ability to successfully recover after the failure (De Carolis et al., 2009; Girotra et al., 2007). Drawing on both perspectives, I investigate investor reactions to NPD failure to determine which perspective prevails and under which contingencies.

In chapter 2, I focus on how organizational capabilities impact investor reactions to NPD failure announcements. I draw on the aforementioned two theoretical perspectives (*ex ante* and *ex post perspectives*) and develop a model that proposes that a firm's financial, innovation, and managerial capabilities either enhance or diminish the loss in market value after NPD failure. My data support such a combined perspective by showing that the development stage where the NPD project fails determines, partly, the way that investors respond. Specifically, I find a significant interaction between development stage and financial capabilities, as well as between development stage and managerial capabilities. However, I do not find a significant interaction effect between development stage and innovative capabilities indicating that more innovative capabilities have an overall negative effect on firm market valuation. My results add to new product development literature since previous studies only focus on one level of analysis while neglecting heterogeneity at other levels of analysis (e.g., Rothaermel and Hess, 2007). Focusing only on one level of analysis implicitly assumes that most of the existing heterogeneity can be found at the chosen level. Consistent with Rothaermel and Hess (2007), I show that a multilevel approach combining *product-level* and *organizational-level* effects is useful to provide a more fine-grained

understanding of investor reactions to negative organizational outcomes of innovation processes. Finally, my findings have also implications for practice since they allow firm managers to better understand the financial consequences of potential NPD failures.

In the second study, presented in chapter 3, I examine how the experience of the firm's top management team can moderate the impact of resources on firm market values after NPD failure. TMTs make decisions necessary for adapting the firm to environmental demands (e.g., Jensen and Zajac, 2004), suggesting that they are also important in adaptation processes after failure events. Moreover, literature shows that TMT attributes influence investor valuation of firms (Goll et al., 2008; Higgins and Gulati, 2006) since these characteristics signal the quality of the firms top management to the market (Zhang and Wiersema, 2009). Combining Upper Echelon theory (Hambrick and Mason, 1984) with resource-based arguments (Barney, 1991), I propose that TMT industry experience and TMT tenure can leverage the buffering effects and mitigate the fostering effects of firm resources in the context of NPD failures. I test my hypotheses by using a sample of late stage failures since these are known to result in substantial losses in stock price (Himmelmann and Schiereck, 2009; Girotra et al. 2007). I find that higher firm revenues can diminish the negative valuation effect of NPD failure while higher firm R&D intensity multiplies this effect. Moreover, my data show that TMT industry experience moderates both effects, while TMT tenure has no significant influence. These findings add to NPD and Upper Echelon literature by considering organizational and managerial resources *interdependently* to provide a more

complete picture of investor reactions to NPD failure than studies that focus only on direct effects of firm resources while neglecting the role of TMTs in allocating firm resources effectively (De Carolis et al., 2009; Girotra et al., 2007). The results also highlight the importance of distinguishing between industry and firm specific managerial experiences since both are relevant for accomplishing different organizational tasks.

The goal of the study presented in chapter 4 is to shed new light on the role that good product news (announcements of NPD success) play within the context of NPD failure announcements to explain heterogeneity of event severity across firms. I propose and test a model concerning parallel announcements of both good and bad news to cope with NPD failure. Linking literature on announcement effects (e.g., Dedman et al., 2008) with resource-based theory (e.g., Barney et al. 2001), I argue that in context of NPD failure announcements positive valuation effects of good firm news are contingent on firm specific characteristics and resource endowments. My data reveal that R&D intensity, cash position, and firm revenues can enhance or diminish the positive effect good product news have on market valuation. Consistent with resource-based theory my results highlight the complex interaction between organizational resources and investor valuation of these interactions. With this study, I add to literature by showing that the positive effect of simultaneously with failure announced good product news is not equal for all firms, but depends significantly on firm specific resource endowments. Moreover, from a methodological perspective, this event study emphasizes that the analysis of overlapping events, rather than eliminating them from the sample, can provide

interesting insights since managers of innovative firms can use simultaneous news announcements as an effective communication strategy with investors.

The final study, introduced in chapter 5, focuses on the impact of patent stock on firm market valuation in case of NPD failure. While existing patent literature emphasizes that patent stocks are a key resource of innovative firms on which investors build up expectations regarding future cash flows and returns (Levitas and McFadyen, 2009; Himmelmann and Schiereck, 2009), the role of patent stocks during NPD failure is still unexplored. This study seeks to close this gap by examining how patent stocks influence the effect of NPD failure on firm market value, and how firm R&D strategy can moderate this effect. My results show that the relationship between the number of patents a company holds and its market value after NPD failure is U-shaped in nature. This suggests that when patent stocks are comparatively small *ex ante* investor expectations of NPD success increase with larger patent stocks and lead to larger disappointments when failure occurs. However, when patent stocks are comparatively large, they can also create *ex post* expectations regarding future potential for firm recovery. I highlight that this potential is contingent on the firm's level of R&D intensity such that only for firms with high R&D intensity large patent stocks signal substantial recovery potential.

In conclusion, my results highlight the importance of *conjoint consideration* of product-level, managerial-level, and organizational-level effects in explaining investor reactions to NPD outcomes. Investigating this research gap is important for better understanding of why some innovative firms suffer more after NPD

failure than other. By doing so, the present thesis provides a more fine-grained picture of investor reactions to NPD failures and advances our understanding of the complexity of these reactions.

### 6.2 New research avenues

In the introduction of this thesis I illustrate that since the foundation of Genentech in 1978, the biotechnology sector has gained substantial economic importance and now significantly impacts our daily life. With a steadily growing and aging population and their increasing medical needs, in concert with the enormous market potential of the biotech sector in advancing other industries, it is a common opinion that the impact of biotechnology will keep growing in the coming years. However, this sector simultaneously offers enormous growth potential and high failure risks. Due to the capital and time intensive new drug development process, failure rates are significant. Thus, it is important that research focuses on failure of biotechnological NPD projects and helps to understand the financial consequences of failures for firms.

In this thesis, I contribute to this growing stream of literature with four event studies analyzing the impact that observable firm resources and capabilities have on market valuation of innovative firms after NPD failure. While each study is limited, thus providing opportunities for future research, there is also a need for researchers to explore other fields. I will close this thesis by suggesting new avenues for scholars that are still underexplored in the literature on new product development failure and that address some of the limitations of the thesis' studies.

The first limitation of this thesis results from my focus on US biotechnology companies, and thus on a single innovation-driven industry. While this sampling technique rules out methodological threats (e.g., Zheng et al., 2010), it raises the question of generalizability to a larger population. Further, caution must be taken when transferring empirical results from a single industry to a larger population. However, I hope that future research will verify my findings in other innovation-driven sectors such as the automotive or the solar industry in order to shed more light on the applicability of my findings across different settings.

Second, while my studies follow others (De Carolis et al., 2009; Himmelmann and Schiereck, 2009; Campart and Pfister, 2007; Girotra et al., 2007) in analyzing how investors react immediately after NPD failure, scholars could investigate in a further step whether short term effects also hold in the long term. Previous studies in this field only focus on narrow event windows, ranging from three-day event windows (e.g. De Carolis et al., 2009) to eight-day event windows (e.g. Girotra et al., 2007). But what happens to these companies in the long run? Do firms loosing less market value directly after NPD failure perform better in the long run, e.g., half a year or a year after the failure event? Are firms that lost more than 50% in market value after NPD failure able to successfully recover? And which factors are the drivers for firm recovery? Similarly, another interesting research question could be whether the loss in firm market value after NPD failure is impacted by the performance of the firm's stock price in the period before the NPD failure occurs. For example, it might be the case that firms that performed well in the past suffer significantly more than firms that experience only moderate stock

price performance (e.g., Himmelmann and Schiereck, 2009). Thus, there appear to be ample research opportunities for scholars to improve our understanding of the impact of NPD failures by extending the time period studied before and after failure occurs.

Further, my approach is limited by the fact that since I focus exclusively on companies listed on the NASDAQ Biotechnology Index in order to better operationalize the relative difference between the benchmark index and the firm's stock price after NPD failure. Although my analysis is consistent with Hendricks and Singhal's (2008) arguments that measurement of abnormal returns by using a fitting index is beneficial to avoid confounding events that are industry-specific, more work is needed to investigate alternative measures. For instance, one might analyze financial consequences of NPD failures by using market to book ratios instead of abnormal returns in order to gain a more objective picture on the real firm value loss. This might open up another fruitful opportunity for scholars to contribute to our understanding of the potential impact of speculations and strategic behavior of biotech investors.

Finally, all studies in this thesis are limited by the fact that other project-level, managerial-level, or organizational-level characteristics and resources can influence the NPD failure announcement itself and, consequently, investor valuation of the firm. For instance, future research can shed more light on the potential impact of simultaneously announced financial statements as well as the role of simultaneously announced changes in the firm's other resources, for example its top management team. Moreover, it appears to be beneficial to explore

the role of investor structure and strategic alliances in this context. This research would shed more light on investor reactions to NPD failure and would help firm managers to better anticipate the processes at work when they have to announce bad failure news to market.

In conclusion, all the limitations I note illustrate that research on biotechnological NPD failure is a growing but underexplored area with fruitful avenues for future research. My thesis seeks to broaden our understanding of investor behaviors in this context. To shed new light on the complex relationship between negative NPD outcomes and investor reactions, research should link findings from the new product development and management literatures with other disciplines such as finance in order to further explore this exciting road ahead.

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# 8 Summary in German

Diese Dissertation mit dem Titel „Investor Reactions to New Product Development Failure in the Biotechnology Industry“ untersucht den Einfluss von fehlgeschlagenen Innovationsprojekten auf die Marktbewertung innovativer Technologiefirmen am Beispiel amerikanischer Biotechnologieunternehmen. Basierend auf dem Wissen, dass erfolgreiche Innovationsprojekte eine treibende Kraft unserer Volkswirtschaft darstellen, betrachtet diese Arbeit den in der betrieblichen Praxis häufigen Fall, dass Innovationsprojekte scheitern und untersucht die damit verbundenen Konsequenzen für die Unternehmensbewertung. Die Forschungsfragen beziehen sich dabei auf den Einfluss von (1) Unternehmensressourcen, (2) Managementerfahrung, (3) gleichzeitig veröffentlichten positiven Unternehmensnachrichten sowie (4) Unternehmenspatenten auf die Marktbewertung von Unternehmen nach Bekanntgabe eines fehlgeschlagenen Innovationsprojektes.

Forschung zu gescheiterten Projekten ist besonders in innovationsgetriebenen Industrien von erheblicher Bedeutung, da in diesen Sektoren mit dem Fehlschlag zumeist erhebliche monetäre und nicht-monetäre Ressourcen verloren gehen. Vor dem Hintergrund, dass Investoren Unternehmensbewertungen auf der Basis künftig zu erwartender Gewinne und Renditen vornehmen, können gescheiterte Innovationsprojekte zu erheblichen Wertverlusten führen. Die vorliegende Arbeit soll die finanziellen Folgen fehlgeschlagener Innovationsprojekte für die Bewertung von innovativen Unternehmen aufzeigen und

Implikationen sowohl für theoretische Entwicklungen in der wissenschaftlichen Literatur als auch für Manager von Unternehmen und deren Investoren aufzeigen.

Um diese Ziele zu erreichen wurden im Rahmen dieser Dissertation mittels verschiedener Ereignisstudien Fehlschläge von Produktentwicklungen amerikanischen Biotechnologieunternehmen untersucht. Um dabei die Vergleichbarkeit der Unternehmen zu gewährleisten, wurden in einem ersten Schritt all jene Biotechnologieunternehmen ermittelt, die (i) im Zeitraum 1994-2008 im NASDAQ Biotechnology Index geführt wurden und (ii) deren Geschäftszweck die Entwicklung neuer Medikamente darstellt (rote Biotechnologie). Im nächsten Schritt identifizierte ich mit Hilfe der Recombinat Capital Database die Daten von 593 biotechnologischen Fehlschlägen für den Zeitraum 1994-2008. Anschließend erfolgte der Abgleich aller Daten mit den Pressemitteilungen der Unternehmen zur Validitätsprüfung. Zusätzlich wurde der exakte Tag der Veröffentlichung eines Fehlschlages ermittelt. Diese taggenaue Validierung stellt eine Grundvoraussetzung für die Anwendung von Ereignisstudien dar und wird häufig als Begründung für geringe Stichprobengrößen innerhalb dieses Forschungsgebietes angeführt.

Mit dem Ziel, exakte Informationen über die zum Zeitpunkt des Fehlschlages vorhandenen Firmencharakteristka zu generieren, wurden im Rahmen der Dissertation weitere umfangreiche Datenerhebungen vorgenommen. Dabei habe ich zunächst mit Hilfe von öffentlich zugänglichen 10-K SEC Fillings (verpflichtend zu erstellende Jahresberichte börsennotierter US-Unternehmen) umfassende Kennzahlen aller Biotechnologieunternehmen zum Zeitpunkt des Fehlschlages gesammelt. Im nächsten Schritt erhob ich die Zusammensetzung und die

Lebensläufe der Managementteams mit Hilfe von 14-A SEC Fillings. Im letzten Schritt der Datenerhebung habe ich alle Kursnotierungen des NASDAQ Biotechnology Index von 1994 bis 2008 in die Datenbank eingepflegt und schließlich alle Börsenkurse der Biotechnologieunternehmen für den jeweiligen Zeitraum des Fehlschlages erhoben. Basierend auf der geschilderten Datenerhebung entstanden vier Ereignisstudien, die aus jeweils unterschiedlichen Blickwinkeln die Reaktion von Investoren auf die Bekanntgabe von fehlgeschlagenen Innovationsprojekten untersuchen.

Die erste Studie in Kapitel 2 befasst sich mit dem Einfluss von Unternehmensressourcen auf die Bewertung von innovativen Biotechnologiefirmen infolge der Bekanntgabe eines fehlgeschlagenen Innovationsprojektes. Diese Studie ist dadurch motiviert, dass vorangegangene wissenschaftliche Arbeiten unternehmensspezifische Ressourcen als einen möglichen ‚Puffer' für kritische Unternehmensphasen herausgearbeitet haben. Im Gegensatz dazu belegen andere Studien, dass vorhandene Unternehmensressoucen negative Bewertungseffekte aufgrund entäuschter Markterwartungen nach einem Scheitern ebenso verstärken können. Mittels deskriptiver Statistiken und Regressionsanalysen zeigt die vorliegende Studie, dass bei der Bekanntgabe eines Fehlschlages der Marktwert eines innovativen Biotechnologieunternehmens durchschnittlich 252 Mio. $US verliert und unternehmensspezifische Charakteristika - liquide Mittel oder Forschungsintensität - diesen negativen Effekt signifikant verstärken können. Darüber hinaus belegen die Ergebnisse dieser Studie, dass die Entwicklungsstufe des gescheiterten Innovationsprojektes einen moderierenden Einfluss auf diese

Effekte hat und die Investorenbewertung unternehmensspezifischer Resourcen im Falle eines fehlgeschlagenen Innovationsprojektes in Abhängigkeit von unterschiedlichen Entwicklungstufen erfolgt. Eine derartige Untersuchung erlaubt Implikationen sowohl für ein besseres wissenschaftliches Verständnis von Investorenreaktionen auf fundamental negative Ereignisse als auch für das Verhalten von Managern innovativer Biotechnologieunternehmen.

Eine zweite Ereignisstudie zur Investorenbewertung von fehlgeschlagenen Innovationsprojekten ist in Kapitel 3 angeführt. Untersuchungsgegenstand dieser Studie ist der Einfluss von Managementerfahrung des Top Management Teams im Kontext fehlgeschlagener Innovationsprojekte sowie deren potentielle Interaktion mit unternehmensspezifischen Ressourcenausstattungen. Die Ergebnisse zeigen, dass industrie-spezifische Managementerfahrung den positiven Einfluß von Unternehmenseigenschaften, insbesondere hohem Umsatz, verstärkt und den negativen Einfluß anderer Firmeneigenschaften, insbesondere Forschungsintensität, abmildert. Im Gegensatz zu industrie-spezifischer Managementerfahrung kann diese Studie für firmen-spezifische Managementerfahrung keinen Einfluss auf die Investorenreaktion im Zuge der Bekanntgabe eines Fehlschlages bestätigen. Die Begründung hierfür baut auf bestehende Studien im Bereich der Upper Echelon Theorie auf und wird darin gesehen, dass Investoren hinsichtlich einer möglichen Erholung des Unternehmens nach einem Fehlschlag Managementerfahrung über die Unternehmensgrenzen hinaus als bedeutend wichtiger bewerten als firmen-spezifische Managementerfahrung. Erstmals wird in dieser Studie die Interaktion von Unternehmenscharakteristika und Managementeigenschaften untersucht. Damit

trägt diese Studie grundlegend zu einem besseren Verständnis hinsichtlich der Rolle des Managements bei der Investorenbewertung fundamental negativer Ereignissen bei.

Die dritte Ereignisstudie in Kapitel 4 widmet sich der Fragestellung, inwieweit die Investorenbewertung eines fehlgeschlagenen Innovationsprojektes durch die Art der Unternehmenskommunikation beinflusst wird. Hierbei steht der potentielle Einfluss einer gleichzeitig mit der Fehlschlag-Nachricht veröffentlichten positiven Produktnachricht bezüglich eines anderen Innovationsprojektes im Mittelpunkt der Untersuchung. Mit Hilfe von Regressionsanalysen über unterschiedliche Ereignisfenster hinweg wird analysiert, inwieweit die Wirkung einer gleichzeitig veröffentlichten positiven Nachricht von den im Unternehmen vorhandenen Ressourcen abhängt. Die Ergebnisse dieser Studie belegen einerseits den – erwartet - positiven Einfluss von gleichzeitig mit dem Fehlschlag veröffentlichten guten Produktnachrichten und andererseits, dass dieser Effekt maßgeblich mit der individuellen Ressourcenausstattung eines innovativen Technologieunternehmens variiert. Möglichkeiten und Spielräume der Unternehmenskommunikation werden dargelegt und es wird aufgezeigt, wie unterschiedliche Kommunikationsstrategien auf die Investorenbewertung im Falle eines fehlgeschlagenen Innovationsprojektes wirken.

In der vierten und letzten Ereignisstudie in Kapitel 5 wird der Einfluss von Patenten als immaterielle Vermögensgegenstände auf die Bewertung von gescheiterten Innovationsprojekten untersucht. Ziel dieser Analyse ist es, herauszufinden ob Investoren das Vorhandensein eines umfassenden Patentpools

als positiv - im Sinne der Basis für eine Erholung nach dem Fehlschlag – oder als negativ aufgrund enttäuschter Renditeerwartungen bewerten. Die abgeleitete Hypothese, dass dieser Zusammenhang einen U-förmigen Verlauf hat, wird durch die Verknüpfung verschiedener Literaturstränge begründet. Zentrales Argument ist hierbei, dass ein großer Patentstock im Falle eines Fehlschlages einerseits zu mehr Enttäuschung von Investorenerwartungen führt, andererseits aber ebenso positiv im Sinne einer Basis für künftige Innovationen bewertet wird. Anschließend wird diese Vermutung mit Hilfe von Regressionsanalysen überprüft. Es zeigt sich über verschiedene Ereignisfenster hinweg, dass im Falle von fehlgeschlagenen Innovationsprojekten Patente einen substantiell negativen Einfluss auf die Markt-bewertung innovativer Biotechnologieunternehmen nach einem Fehlschlag in der Produktentwicklung haben. Darüber hinaus belegen die Ergebnisse dieser Studie, dass dieser Effekt in Abhängigkeit unterschiedlicher Unternehmensstrategien signifikant variiert. So zeigt sich beispielsweise für forschungsintensive Technologieunternehmen der postulierte U-förmige Zusammenhang zwischen der Patentanzahl und der Marktbewertung nach einem Fehlschlag. Hingegen lässt sich für wenig forschungsintensive Unternehmen dieser U-förmige Zusammenhang nicht signifikant bestätigen. Damit erweitert dieser Artikel bestehendes Wissen im Bereich des Innovationsmanagements und füllt darüber hinaus eine bestehende Lücke in der Patent-Literatur, da die Wertrelevanz von Patenten bisher lediglich aus dem Blickwinkel positiver Unternehmens-nachrichten untersucht wurde.

In Kapitel 6 werden abschließend die Ergebnisse der empirschen Studien diskutiert sowie ein Ausblick auf zukünftige Forschungsmöglichkeiten gegeben.

# 9 Appendix

The appendix contains a short description of the new product development failure database on which all chapters of this thesis build on.

**New product development failure database**

- collected between 07/2008 – 03/2010
- Time focus 1994-2008
- NPD failure of publicly traded US biotechnology firms (NASDAQ Biotechnology Index)
- Data sources:
    - Recombinant Capital Database (ReCap)
    - EPO Worldwide Patent Statistical Database (PATSTAT)
    - MarketWatch database
    - LexisNexis database
    - Firm press releases
    - The Wall Street Journal
    - Company web pages

*Product level data:*

- Event day (all data points by SEC and ReCap had to be validated by press releases)
- Development stage where the NPD project fails in
    - Clinical phase I
    - Clinical phase 2
    - Clinical phase 3
    - Clinical phase IV (NDA review)
- Indication
- Disease
- Technology

- Alliances
- Number of products
- Number of failure before
- Parallel good product news
    - Good product news preclinical development
    - Good product news Clinical phase I
    - Good product news Clinical phase II
    - Good product news Clinical phase III
    - Good product news Clinical phase IV (NDA review)
    - Good news results
    - Good news restructuring
- Patent stock data (at the time of NPD failure)
    - Number of patent applications
    - Number of patents
    - Forward citations
    - Backward citations
    - Pipeline 5years
    - Pipeline 10years
    - Pipeline 15 years
    - Pipeline 20years

*Organizational level data:*

- Company headquarter
- Firm age
- Number of employees
- R&D expenses
- R&D intensity
- Firm revenue
- Firm cash
- Total assets

- Long term debts
- Return on assets (ROA)
- Stockholder's equity
- Earnings per share (EPS)
- Number of outstanding shares
- Market capitalization
- Investor structure

*Management level data:*

- TMT-size
- TMT-age
- TMT-tenure
- TMT-industry experience
- TMT-heterogeneity

Stock prices data:

- Cumulative Abnormal Return (CAR)
- Short term CAR
    - CAR (-1,0)
    - CAR (-1,+1)
    - CAR (-2,+2)
    - CAR (-3,+3)
- Long term CAR
    - CAR (-1,+15)
    - CAR (-1,+30)
    - CAR (-1,+60)
    - CAR (-1,+90)

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Hiermit erkläre ich,

1. dass mir die geltende Promotionsordnung bekannt ist;

2. dass ich die Dissertation selbst angefertigt, keine Textabschnitte eines Dritten oder eigener Prüfungsarbeiten ohne Kennzeichnung übernommen und alle von mir benutzten Hilfsmittel, persönlichen Mitteilungen und Quellen in meiner Arbeit angegeben habe;

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Jena, den 30. Juni 2010 ……

(Robin Bürger)